Automotive Vents

White Paper

Venting Solutions for Clear Visibility

How to Reliably Protect Headlamps Against Condensation as well as Dirt and Water Ingress

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Headlamps have to cope with environmental conditions that change every day. What's more, they have to be protected against dust, dirt, deposits, and condensation if they are to work effectively and guarantee drivers a clear view at all times. Various options are available to automobile manufacturers and suppliers for removing moisture from headlamps. When selecting a venting membrane as an option, the solution must be able to equalize pressure within the headlamp housing, form an effective barrier against dirt and water ingress, and be able to reduce condensation.

Three Moisture Sources

Moisture in headlamps comes from three main sources **(Figure 1)**. The most common of the three is desorption, which is triggered by differences in temperature. When the light source is switched off, the temperature drops and the plastic that the headlamps are made of soaks up moisture like a sponge. When the light source is switched on again, the temperature rises, releasing this accumulated moisture from the material **(Figure 2)**. At the same time, the dew point rises, which can cause condensation to form at the coldest place in the headlamp. The next time the light source is switched off, the temperature drops and the plastic absorbs moisture. This process accounts for roughly 80% of the moisture in headlamps.

Permeation is the second source of moisture: a process by which water vapor from the outside continuously diffuses through the plastic into the housing interior over a longer period.

The third cause of moisture is the vent itself, through which moisture can get in and out of the headlamp.

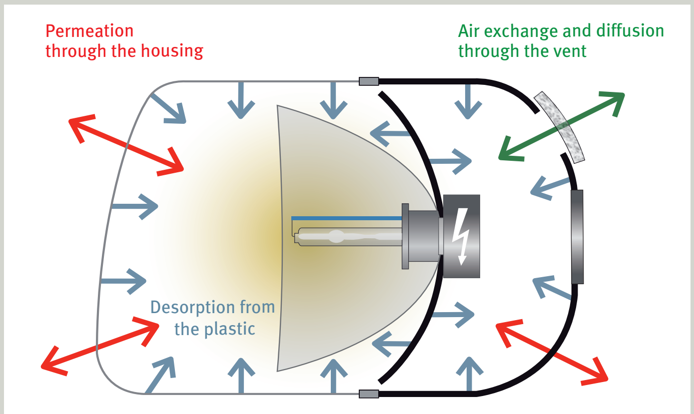

Figure 1: Three causes of moisture in vehicle headlamps

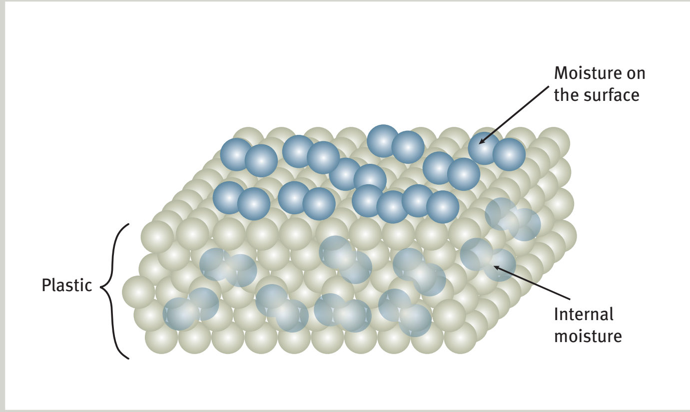

Figure 2: Over 50 % of all the moisture that desorbs is surface moisture

Measuring Moisture

Although moisture levels in headlamps are frequently expressed in terms of relative humidity, specifying the dew point is actually much more useful and to the point, as it does not depend on prevailing temperatures. This will become clear in the following example, which demonstrates the correlation between dew point and temperature. In the example, moisture is measured under laboratory conditions. At 22 °C and 50 % relative humidity, the dew point is 11 °C **(Figure 3)**.

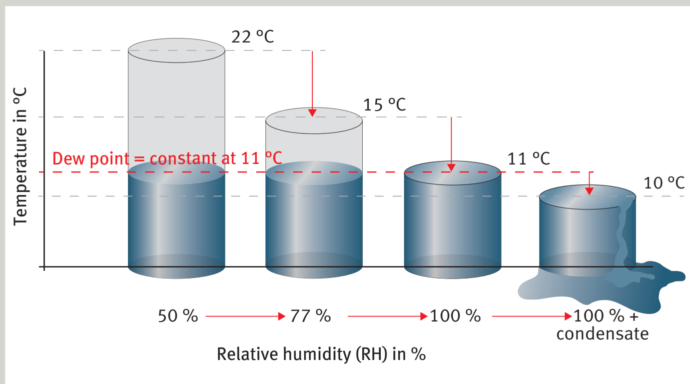

Figure 3: The water glass analogy demonstrates the correlation between temperature and humidity

If the temperature falls to 15 °C, relative humidity climbs to 77 %. The dew point remains constant. At 11 °C, relative humidity reaches 100 %, meaning that the air is saturated and cannot absorb any more moisture. If the temperature drops below the dew point, condensation occurs.

Conducting Moisture Outside by Means of Convection or Diffusion

Essentially, there are two methods of removing moisture and ventilating headlamps: convection and diffusion. In this context, convection involves open, transverse ventilation and works using at least two venting tubes, which conduct moisture outside by circulating air. This process is triggered by pressure differentials, produced when temperatures increase (e.g. when the headlamp is switched on) or as a result of movement while the vehicle is in motion. These pressure differentials create an air current that carries moist air outside **(Figure 4)**. Ambient air is drawn in through the lower opening and flows out again through the upper opening. The disadvantage of an open venting solution such as this, however, is that dust, particles of dirt, insects, etc. get into the headlamp along with the suctioned air. Also, convection works only when the vehicle is in motion or the headlamp is switched on. On top of this, there is often the problem that air cannot circulate to the required extent around headlamps due to the large number of components crammed together in the engine compartment.

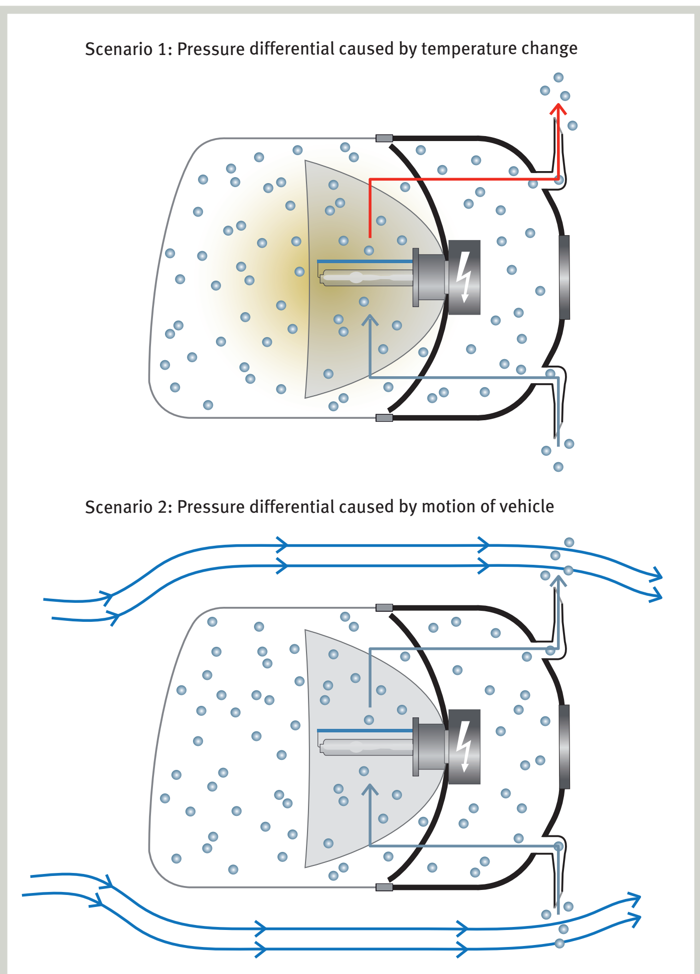

Figure 4: Temperature rise and vehicle motion lead to air circulation in headlamp

A more effective means of removing moisture from headlamps is diffusion. This physical process causes water vapor to move from regions of high concentration to regions of low concentration. The following law of diffusion describes this movement: $\mathbf{v_D = -D * A * dc/dx}$, whereby v_D is the diffusion rate and D is the diffusion constant. Accordingly, in order to increase the diffusion rate, you must increase either the exchange surface A and/or the concentration gradient dc/dx. Here, dc represents the concentration difference (dc = c1 - c2), and dx is the distance between the concentrations. The influence of exchange surface A on the diffusion rate is illustrated in **Figure 5**.

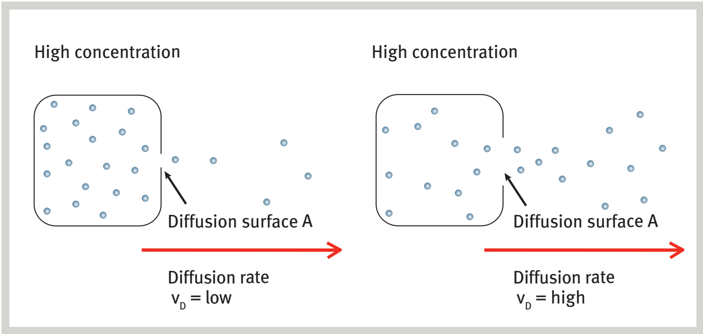

Figure 5: The larger the diffusion surface, the higher the diffusion rate

In addition, the diffusion rate increases when the concentration gradient dc/dx is as high as possible **(Figure 6)**. This happens when the following conditions between the inside and the outside of the headlamp are met:

- the concentration difference dc is as big as possible
- the distance dx is as small as possible.

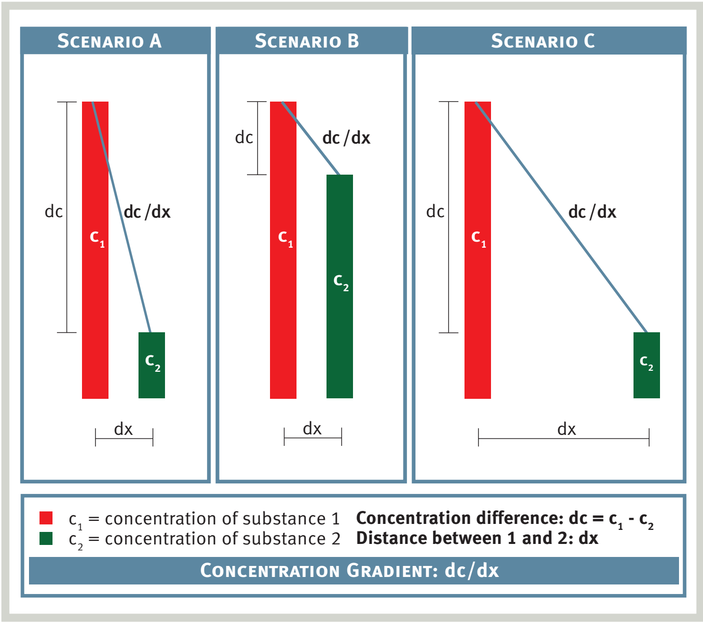

Figure 6: The diffusion rate increases as the concentration gradient rises

Cap Vents Versus Venting Membrane

There are two practical options for facilitating diffusion: cap vents and venting membranes. As **Figure 7** shows, a venting membrane that you simply stick onto the headlamp housing (adhesive vent) enables better condensation reduction. The exchange surface A of an adhesive vent is typically larger than that of a cap vent, which has a positive effect on the diffusion rate. In addition, adhesive vents have an average thickness of only around 0.3 mm, whereas cap vents are often about 20 mm in length. As a consequence, the distance (dx) that the moist air has to overcome is significantly higher with cap vents and leads to poorer condensation reduction. Furthermore, dust, dirt, and deposits can clog up the venting path in cap vents, further obstructing ventilation.

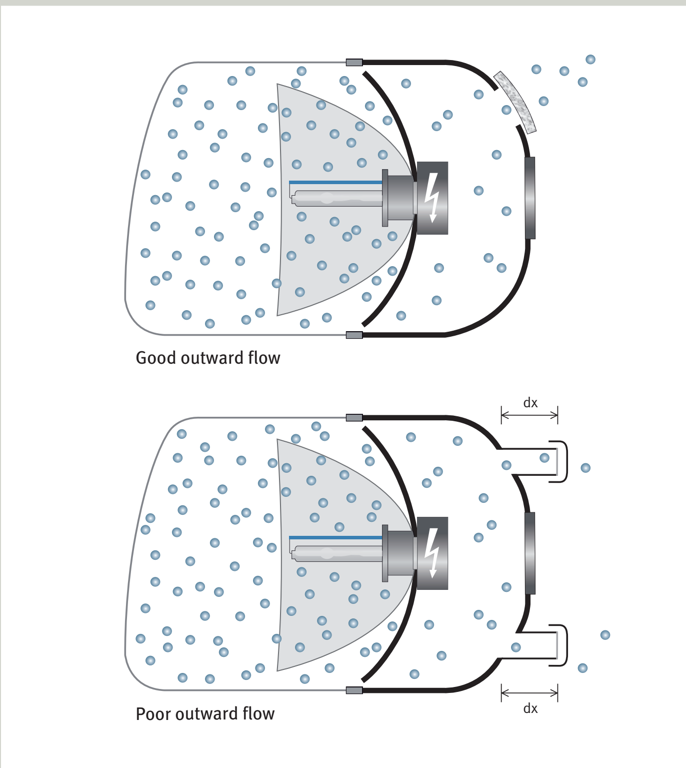

Figure 7: Venting membranes offer escaping air the shortest path and the least resistance

The Larger the Ventilation Surface, the Higher the Diffusion Performance

The easiest way to demonstrate the performance of venting components in relation to moisture transfer is to carry out a moisture vapor transmission rate (MVTR) test **(Figure 8)**. This involves filling a vessel with 100 ml of water, sealing it airtight, and fitting it with a venting product. The container is weighed daily for two weeks under laboratory conditions (22 °C, 50 % humidity) in order to measure the volume of water that has diffused every day. Measurements show that approx. 550 mg of liquid can diffuse through the GORE® Automotive Vents Series AVS 9 in one day. Meanwhile, the GORE® Automotive Vents Series AVS 5, which is made from the same material as the AVS 9, transports only approx. 125 mg of liquid a day. This demonstrates the influence of exchange surface A. The correlation between exchange surface (AVS 9: 285 mm^2/AVS 5: 65 mm^2) and moisture transported per day is linear. However, even the smaller AVS 5's moisture vapor transmission rate is double that of tube vents or cap vents. This makes the AVS 5 particularly well suited for use in smaller housings such as tail and fog lamps.

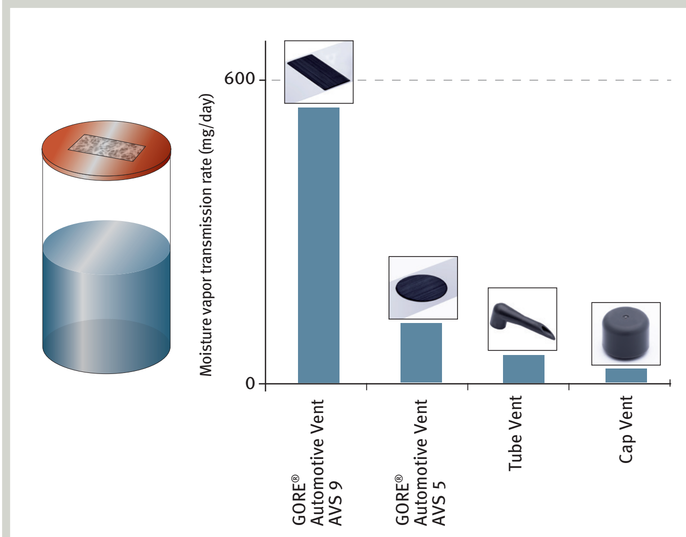

Figure 8: The MVTR test demonstrates the outstanding diffusion performance of GORE® Automotive Vents

GORE® Automotive Vents stand out from other solutions through both their diffusion and their protection performance. Tube vents use convection, which enables efficient condensation reduction while the vehicle is in motion, but does not protect headlamps against dust, dirt, deposits, or water. In contrast, cap vents offer effective protection against dirt, etc., but they provide only limited diffusion, which leads to poor condensation reduction. The GORE® Automotive Vents Series AVS 9, on the other hand, provides an optimal balance between protection against particle and liquid ingress and reliable, tried-and-tested condensation reduction.

Gore manufactures adhesive vents from expanded polytetrafluoroethylene (ePTFE) **(Figure 9)**. This material is characterized by its extremely close-meshed pores, which are some 20,000 times smaller than a drop of water and keep out even the tiniest droplets and dirt particles, down to a size of 1.0 micrometers. In addition, ePTFE is extremely temperature- and chemical-resistant. Due to its low surface energy, ePTFE possesses outstanding hydrophobic and oleophobic (water- and oil-repelling) properties. These are very important, because

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under the hood the membrane comes into contact with oils, lubricants, detergents, and other typical automotive fluids. However, these oleophobic properties are achieved only by further refining the membranes.

These properties make venting components with ePTFE membranes an ideal solution for protecting headlamps against dirt and maintaining optimal venting performance over the lifetime of the vehicle. With billions of its vents fitted in vehicles worldwide, Gore has established itself as a reliable partner for innovative venting solutions in the automotive industry, and has enjoyed the confidence of numerous big-name manufacturers for many years.

The GORE™ Membrane

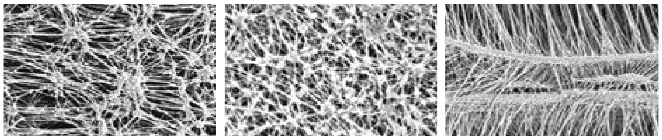

Figure 9: The microporous structure of ePTFE membranes can be specifically adapted to the requirements of different applications

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