OPTIMIZING THE PERFORMANCE AND DURABILITY OF OUTDOOR ELECTRONICS:

FIELD STUDY PROVES GORE® PROTECTIVE VENTS TO BE A LASTING SAFEGUARD

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For electronic equipment to function reliably outdoors, intact sealing of the enclosure is vitally important. These seals are prone to damage due to pressure differentials caused by fluctuating temperatures, and this can compromise the sensitive electronics, resulting in their failure.

Reliable enclosure ventilation using GORE® Protective Vents ensures rapid pressure equalization, minimizes potential pressure spikes and therefore helps to extend service life. At the same time, the patented membrane technology provides reliable protection against water, dust, salt particles and other liquids, and helps to reduce or eliminate condensation inside the enclosure.

In addition to lab tests, Gore regularly carries out field tests in order to achieve realistic material aging due to weather and UV radiation. These tests have a common objective: to demonstrate that GORE® Protective Vents reliably protect the enclosure from contaminants and water ingress over the long term and prevent any loss in performance.

In this white paper, we bring together the results of our ongoing study from the year 2024—a study that Gore has been conducting for eight years, that will continue in Putzbrunn, south of Munich.

Fig. 1: Study location

Design of the Ongoing Study

Fourteen identical aluminum electronic enclosures with neoprene seals were installed in the roof garden of the Gore plant in Putzbrunn. These enclosures have a rating of IP65 which means they are protected against dust ingress (dust tight), have complete protection against contact, and protection against water jets from all directions.

The enclosures were fitted with different GORE® Protective Vents (see Fig. 3: Assignment of vents). One enclosure was purposely not fitted with a vent, in order to generate comparative values with an unventilated enclosure.

Inside the enclosures, data loggers continuously record the relative humidity, temperature and pressure. In addition, an external sensor for recording meteorological ambient values was installed as a reference. The GORE® Protective Vents were exposed to a temperature range of –15°C to +50°C (values measured by the external sensor). In an unventilated enclosure, these temperature differences give rise to pressure changes that can damage the seal.

The enclosures are inspected and the sensor data are being analyzed at regular intervals. The vents are examined and the data relevant to pressure equalization and tightness, such as airflow and water entry pressure (WEP), are being measured.

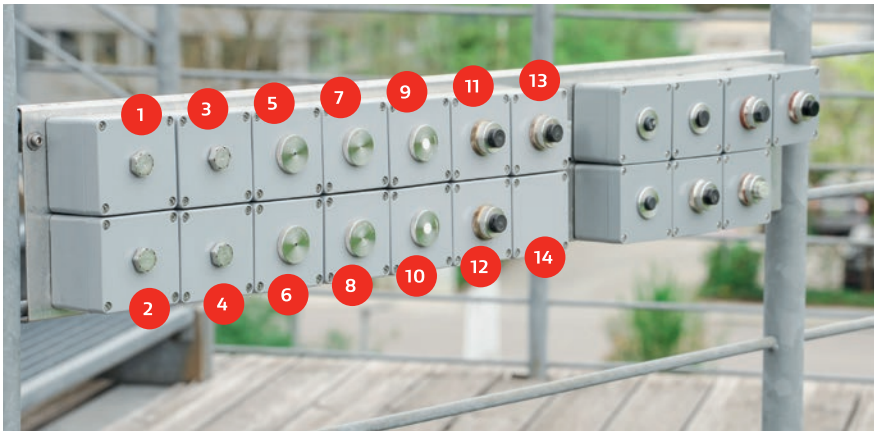

Fig. 2: Enclosure equipped with different GORE® Protective Vents

Number	Description
1–4	GORE® Protective Vents—Screw-In Series (PolyVent Stainless Steel)
5–10	GORE® Protective Vents—Adhesive Series (Series VE7, VE8, VE9)
11–13	GORE® Protective Vents—Snap-In Series (PolyVent Standard)
14	Reference enclosure (no vent)

Fig. 3: Assignment of vents

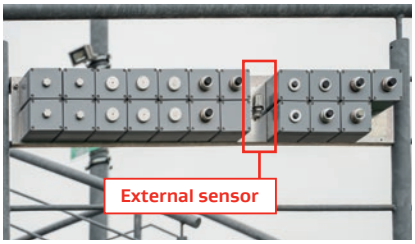

Fig. 4: Position of external sensor

Results

Pressure Equalization

On the basis of the data acquired, it is clear that the ventilation of enclosures with GORE® Protective Vents brings nothing but advantages.

The pressure inside the ventilated enclosures stayed almost exactly in line with the atmospheric pressure (Fig. 5) – and has done so constantly since 2016. Consequently, both the sealing system and the electronics inside the enclosure remained virtually unaffected by pressure.

In the ventilated enclosures, the sensors recorded pressure differentials of max. 19 mbar, whereas differences in pressure of up to 168 mbar were registered in the unventilated enclosure.

In the ventilated enclosures, the sealing systems were subject to virtually no stress. This minimized the risk of moisture entering due to defective seals.

In contrast, high pressure spikes occurred in the unventilated enclosure, exposing the seals to considerable stress and significantly increasing the risk of leakage over their service life.

The illustration below (Fig. 6) shows a comparison of pressure differentials in the ventilated and unventilated enclosures.

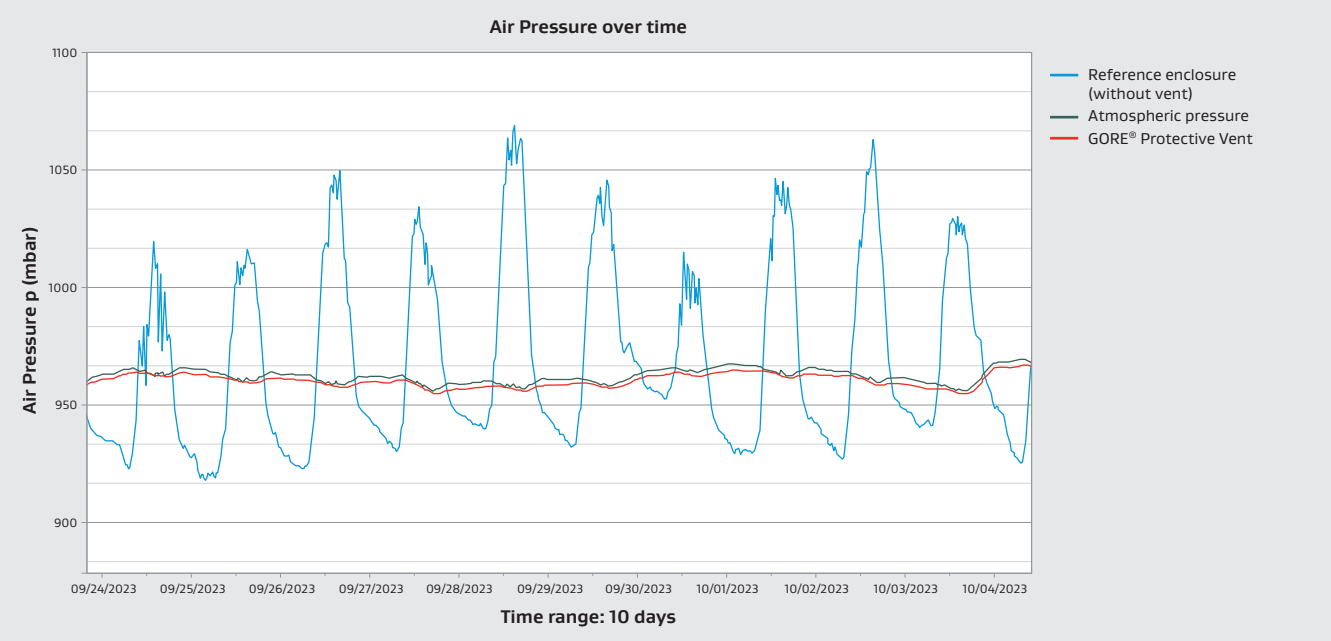

Fig. 5: Example data log of air pressure in the enclosure without vent (blue), compared with an enclosure with GORE® Protective Vent (red) and the outside environment (green). A pressure differential of up to 150 mbar was measured between the ventilated and unventilated enclosures.

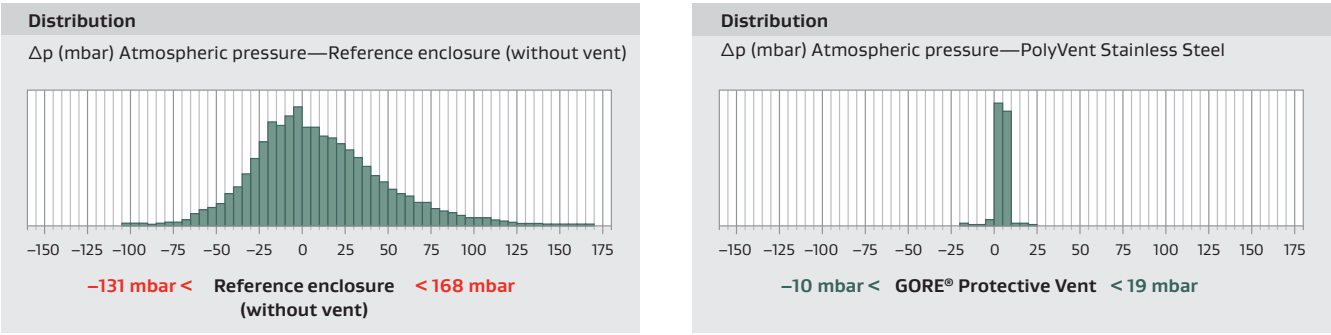

Fig. 6: Distribution and extent of differential pressures in the unventilated enclosure (left) and in a ventilated enclosure (right) since data logging began (May 2022)

Moisture Management

In electronic equipment enclosures, condensation can form if moist air comes into contact with cooler surfaces that are below the dew point of the air. An understanding of the causes of and preventive measures against condensation is crucial in guaranteeing the reliability and durability of electronic components.

Thanks to the microporous structure of the membrane installed in all GORE® Protective Vents, the enclosure is protected against the ingress of water, dust, salt particles and other contaminants. At the same time, moisture can exit the enclosure in the form of water vapor, reducing the risk of condensation.

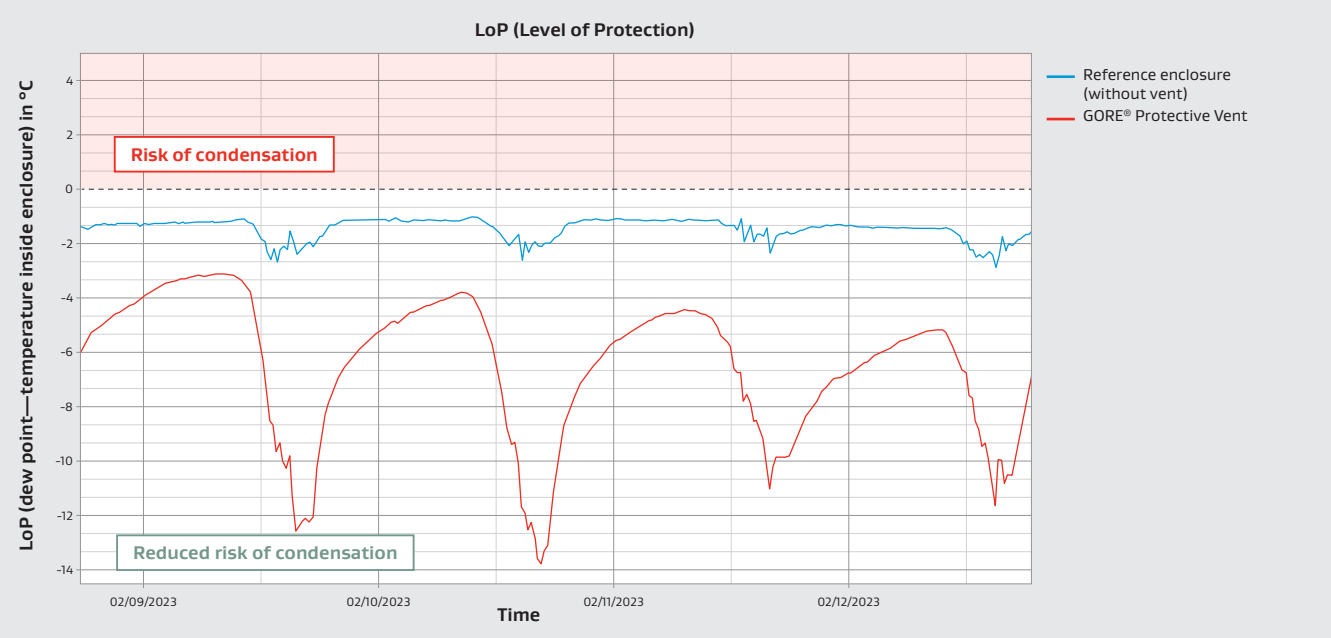

Fig. 7: LoP comparison: enclosure with GORE® Protective Vent and without vent

To better illustrate moisture management, Gore uses a **Level of Protection (LoP) chart**.

The LoP figure indicates the risk of condensation forming. The lower the LoP, the lower the risk of condensation in the enclosure.

$$\mathbf{LoP = T_{dew\ point\ of\ air} - T_{surface\ of\ enclosure}}$$

If the enclosure temperature is **below** the dew point of the air inside the enclosure, condensation can form:

Risk of condensation:
$LoP > 0$ ($T_{dew\ point\ of\ air} > T_{surface\ of\ enclosure}$)

If the enclosure temperature is **above** the dew point of the air inside the enclosure, no condensation forms:

Low risk of condensation:
$LoP < 0$ ($T_{dew\ point\ of\ air} < T_{surface\ of\ enclosure}$)

As a general principle, the lower the dew point and the LoP, the greater the protection against condensation.

The chart above compares the LoP of an enclosure without a vent (reference enclosure) to an enclosure with a GORE® Protective Vent. Here, it can clearly be seen that the enclosure without the GORE® Protective Vent has a higher LoP and therefore significantly greater risk of condensation than an enclosure with a GORE® Protective Vent.

A comparison of relative humidity provides further evidence of well-functioning moisture management. Figure 8 compares the relative humidity of an enclosure without a vent to that of an enclosure with a vent. The data show that with GORE® Protective Vents, relative humidity decreases (red), whereas a high level of humidity (~90%, blue) remains constant inside the enclosure without a vent. In a direct comparison with the unvented enclosure, the relative humidity in enclosures with GORE® Protective Vents falls by as much as 46% (Fig. 8).

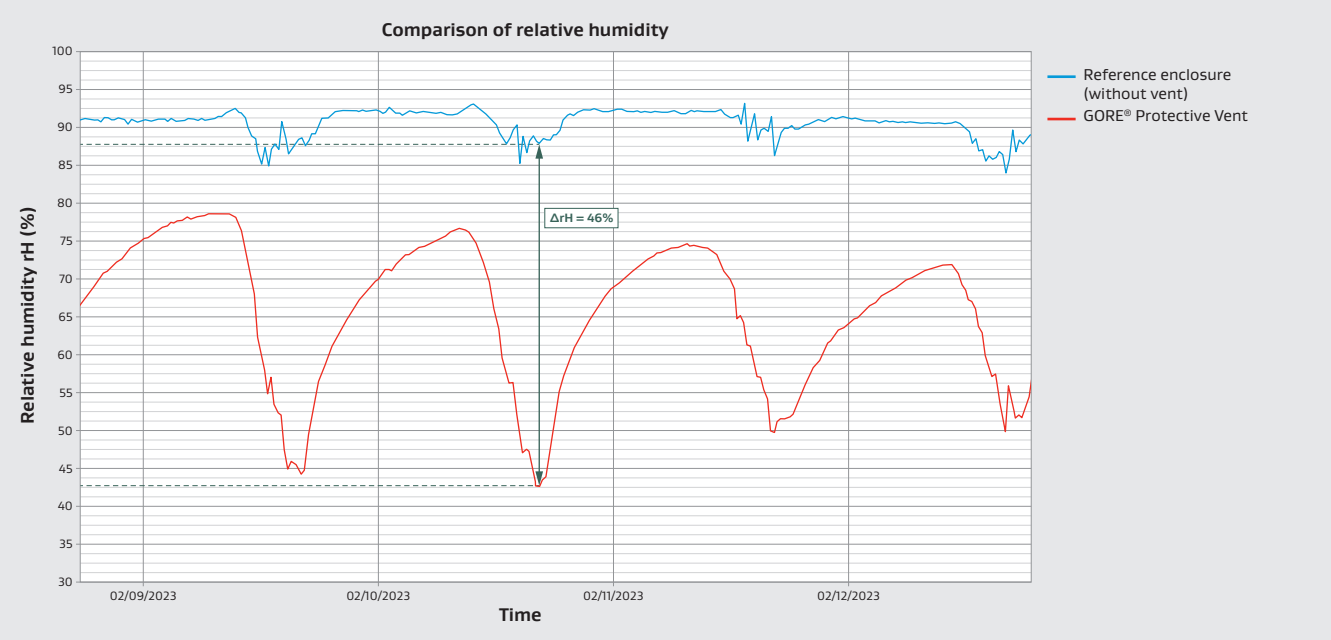

Fig. 8: Comparison of relative humidity: enclosure with GORE® Protective Vent and without vent

Inspection of Vents

At regular intervals, our engineers remove the GORE® Protective Vents used in this study from the enclosures and compare them with brand new vents of the same type.

During this process, all GORE® Protective Vents are examined and the two fundamental characteristics that determine a membrane's performance are tested: the airflow and the water entry pressure (WEP).

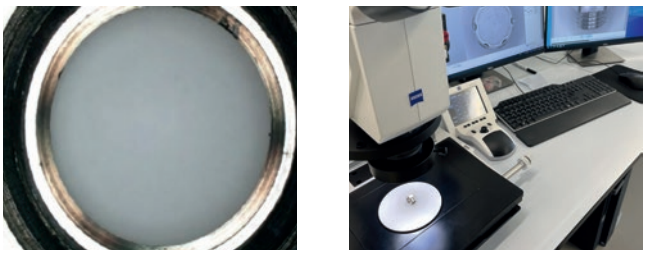

Fig. 9/10: Visual inspection of a GORE® Protective Vent after 8 years

The airflow indicates how much air can flow through the membrane over a given period and at a given differential pressure. The WEP is the hydrostatic pressure (pressure inside a fluid at rest) that the membrane must withstand for a defined period of time.

The results underscore the long-term reliability and durability of these vents. After eight years of these vents being in service, the measurements demonstrate that the airflow of the GORE® Protective Vents has not been impaired in any way whatsoever. The slight increase in the airflow over time is a typical characteristic of the membrane. The positive results of the WEP test also indicate the reliable tightness of the vents over a long period. Figures 11 and 12 illustrate the airflow and eWEP for the PolyVent Stainless Steel model.

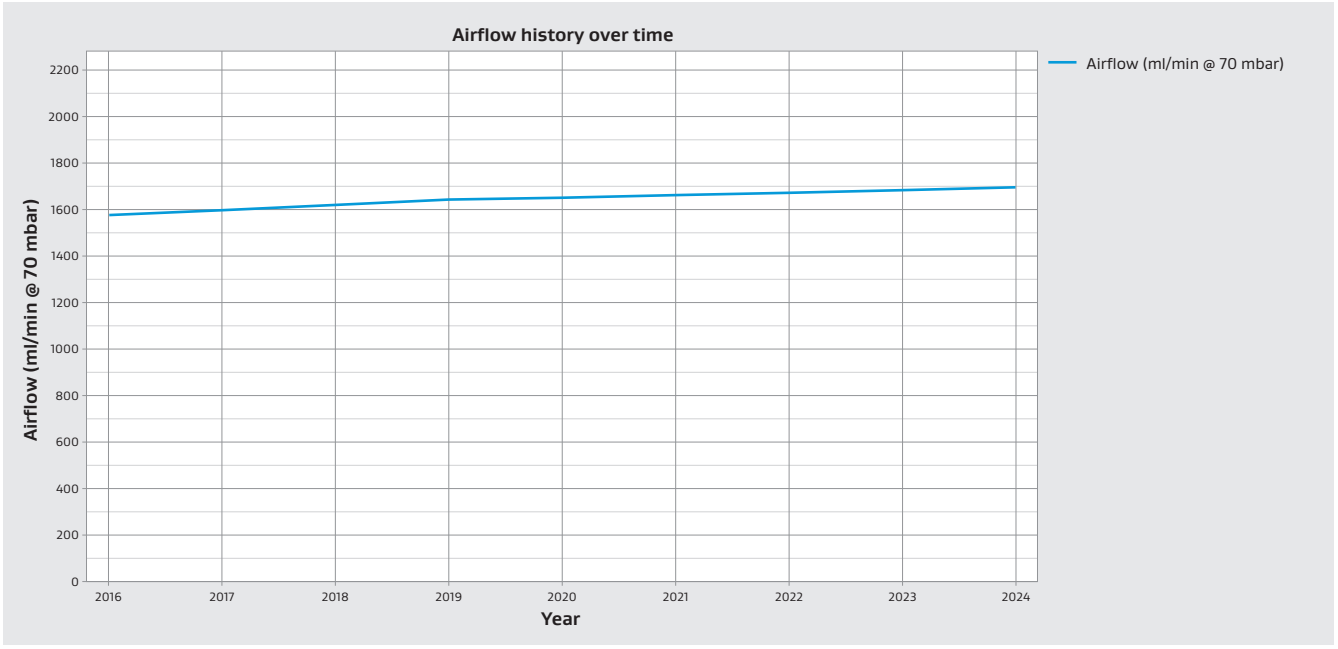

Fig. 11: Airflow characteristic over time (PolyVent Stainless Steel)

	GORE® Protective Vent		
	2016	2021	2024
eWEP (0.3 bar/30 sec)	OK	OK	OK

Fig. 12: Overview of the water entry pressure of a GORE® Protective Vent (PolyVent Stainless Steel)

Summary

The data from this long-term study show that GORE® Protective Vents effectively achieve rapid pressure equalization of pressure differentials and can prevent pressure spikes, and therefore offer reliable and lasting protection for outdoor electronics.

Humidity inside the enclosures is demonstrably reduced, considerably lowering the risk of condensation. Even after 8 years of continuous use, no decline in performance could be found in the GORE® Protective Vents.

This study will continue to run over the next several years.

Notes

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