RELIABILITY IN OUTDOOR ELECTRONIC EQUIPMENT

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Outdoor electronic enclosures often face internal pressure fluctuations that stress housing seals. Over time, this can compromise the seals and reduce equipment reliability. These fluctuations typically occur due to sudden weather and temperature changes in outdoor environments. Once seals fail, contaminants such as rain, dust, and dirt can enter the housing, leading to premature electronic failure. Telecommunications equipment is a clear example of this problem, showing how pressure changes can degrade seals and impact long-term performance.

GORE® Protective Vents are engineered to eliminate stress and damage on seals by allowing air to flow freely in and out of electronic housings. Based on their research on the impact of pressure differentials on sealed enclosures, W. L. Gore & Associates recommends maintaining internal pressure at or below 35 millibars (mbar). Gore's engineering team bases its vent recommendations for each application on such variables as volume of enclosure, amount of internal free space, level of water and contaminant protection required, enclosure materials of construction, and environmental conditions in which the device will be used. By evaluating these variables, Gore is able to specify the best venting solution to reduce the impact of pressure differentials and increase the lifetime performance of outdoor electronic equipment.

To evaluate the performance of GORE® Protective Vents after extended exposure to real-world conditions, Gore decided to test vents that had been in outdoor electronic equipment operating throughout the world for several years. Each vent was evaluated for water protection integrity and airflow.

Test Design

Gore purchased approximately 30 units of used outdoor electronic equipment — tower-mounted amplifiers (TMA) and combiners — that were manufactured between 2003 and 2011. The purchases were made globally to ensure exposure to a full range of harsh environmental conditions — temperature, humidity, rain, salt, sand, etc. Each unit contained a GORE® Adhesive Vent or a GORE® Screw-In Vent (Table 1). All of the vents were engineered to meet IP67 ingress protection when initially installed.

Table 1: Equipment purchased for testing

Equipment Type	Estimated Manufacture Date	GORE® Protective Vent	Active Venting Area (cm^2)	Airflow Specification When New[a] ml/min at 70 mbar
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1
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Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1
TMA	2005	Adhesive Vent Series VE7	1.13	181.0
TMA	2005	Adhesive Vent Series VE7	1.13	181.0
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TMA	2005	Adhesive Vent Series VE7	1.13	181.0
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TMA	2005	Adhesive Vent Series VE7	1.13	181.0
TMA	2005	Adhesive Vent Series VE7	1.13	181.0
TMA	2005	Adhesive Vent Series VE7	1.13	181.0
TMA	2005	Adhesive Vent Series VE7	1.13	3200.0
TMA	2005	Adhesive Vent Series VE7	1.13	3302.0
Combiner	2009	Screw-In Vent M12x1.5	0.50	226.2
TMA	2011	Adhesive Vent Series VE7	1.13	370.9
TMA	2011	Adhesive Vent Series VE7	1.13	370.9
TMA	2011	Adhesive Vent Series VE7	1.13	370.9

a. Because the internal airflow performance of Gore venting products has improved over the past ten years, Gore used the specifications that were published at the time the telecommunications equipment was manufactured.

Each unit of equipment was opened, and both the equipment and the vents were visually inspected for evidence of water and particulate ingress, corrosion, and condensation (Figures 1 and 2).

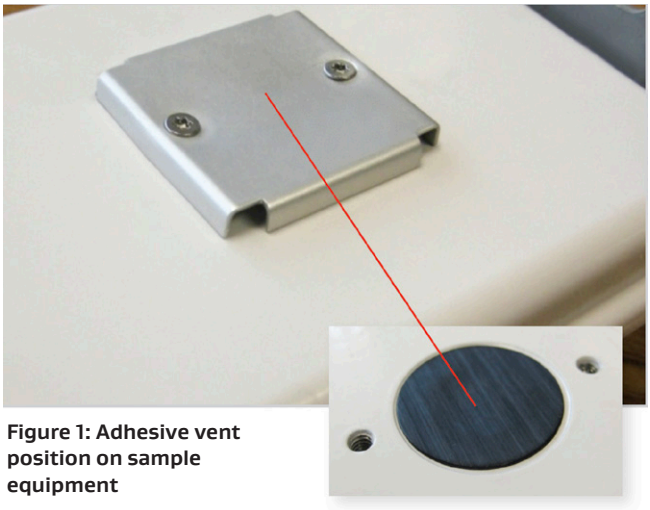


Figure 1: Adhesive vent position on sample equipment



Figure 2: Screw-in vent position on sample equipment

Each GORE® Protective Vent was then subject to airflow testing (Figures 3 and 4):

1. A sensor was placed on either side of the vent to measure the pressure differential.
2. Air was forced through the vent at a rate of 70 millibars (mbar).
3. The measured airflow of the vent was then compared to Gore's performance specifications. Because airflow performance of the venting products has improved over the past ten years, Gore used the typical airflow that were published at the time the equipment was manufactured.

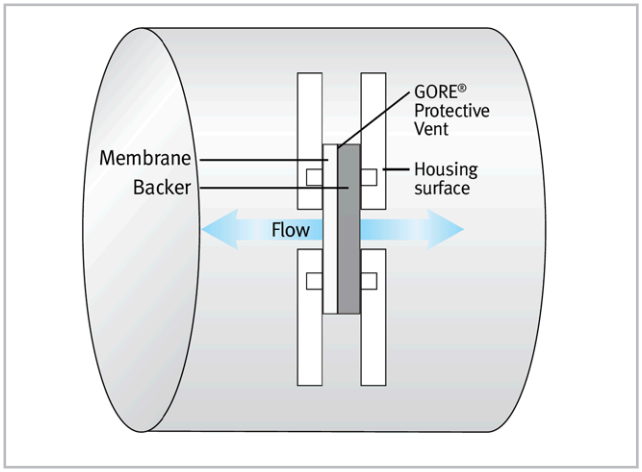


Figure 3: Adhesive vent position during airflow test

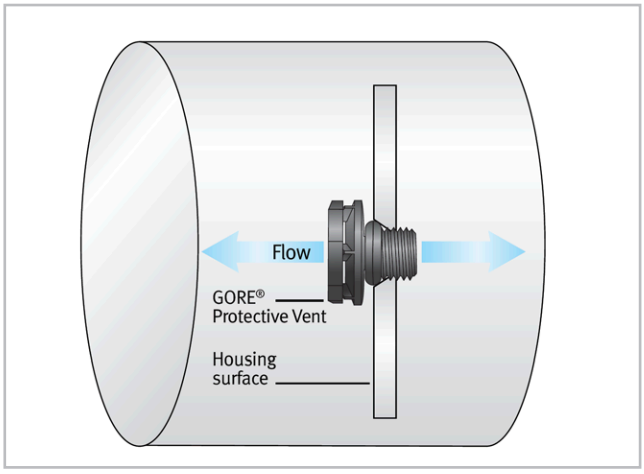


Figure 4: Screw-in vent position during airflow test

Finally, the water resistance and bond integrity of each vent was tested by measuring the minimum pressure required to force water through the vent's membrane (Figures 5 and 6).

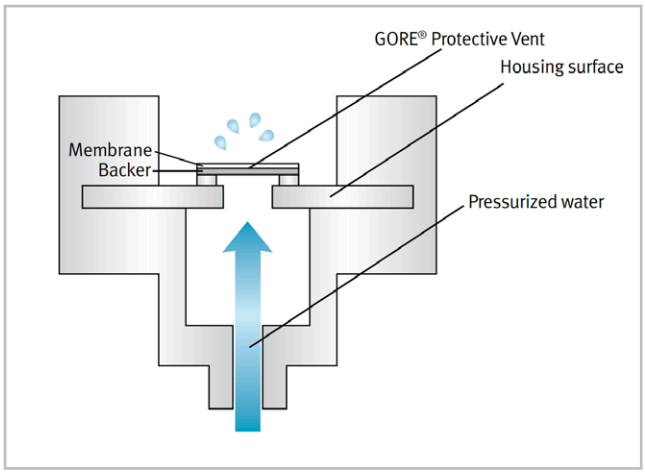


Figure 5: Adhesive vent position within water pressure testing equipment

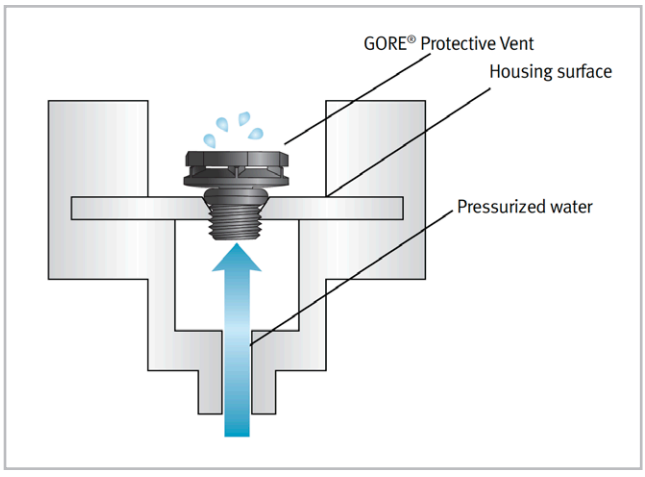


Figure 6: Screw-in vent position in water pressure testing equipment

1. Water pressure was maintained at approximately 103 mbar to simulate 1 meter of water submersion, as required by the Ingress Protection level of IPX7.
2. To pass the test, the vent was required to withstand this level of water pressure for 30 minutes without allowing any water to pass through the membrane, or in some cases, through the adhesive bond on the enclosure.

Inspection Results

The inspection of the equipment showed no evidence of condensation or corrosion (Figure 7). In addition, the seals were intact with no indication of failure or extreme fatigue. Although the equipment could not be functionally tested, it can be assumed that they were in working order because there was no evidence of water or particulate ingress. Also, the form of the vent (i.e., adhesive or screw-in vent) did not show significant signs of wear, as indicated in the results of the vent's airflow and water protective performance.



Figure 7: Internal components of used equipment

Visual inspection of the vents identified that four were compromised. Because there was no evidence of damage to the electronics or housings in which these vents were installed, the damage most likely occurred during or after the equipment was removed from service.

Airflow Results

Of the 29 vents tested, 21 exceeded Gore's typical airflow after several years of exposure to extreme environmental conditions (Table 2). Although the airflow of the remaining eight vents was below Gore's typical airflow, they still provided sufficient airflow to equalize pressure due to the amount of free space in the equipment.

Water Resistance Results

For water resistance, 26 of the 29 vents withstood the specification of approximately 103 mbar for 30 minutes (Table 2). The three vents that failed were identified during the visual inspection as having physical damage that prevented the vent from maintaining its seal.

Table 2: Airflow and water resistance after field use

Equipment Type	Estimated Manufacture Date	GORE® Protective Vent	Active Venting Area (cm^2)	Airflow Specification When New[a] ml/min at 70 mbar	Measured Airflow After Use ml/min at 70 mbar	Water Resistance Test
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	217.1	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	209.6	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	195.5	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	211.4	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	175.7	Failed[b]
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	200.4	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	238.3	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	181.5	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	217.0	Passed
Combiner	2003	Screw-In Vent M12x1.5	0.50	201.1	207.0	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	310.5	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	271.0	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	298.2	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	279.8	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	285.8	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	285.8	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	276.9	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	274.9	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	277.0	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	287.6	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	464.4	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	411.4	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	181.0	453.4	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	3200.0	1453.1	Passed
TMA	2005	Adhesive Vent Series VE7	1.13	3302.0	1199.2	Failed[b]
Combiner	2009	Screw-In Vent M12x1.5	0.50	226.2	168.2	Failed[b]
TMA	2011	Adhesive Vent Series VE7	1.13	370.9	320.9	Passed
TMA	2011	Adhesive Vent Series VE7	1.13	370.9	283.6	Passed
TMA	2011	Adhesive Vent Series VE7	1.13	370.9	509.8	Passed

a. Because the internal airflow performance of Gore venting products has improved over the past ten years, Gore used the specifications that were published at the time the telecommunications equipment was manufactured.

b. Failure was most likely due to damage during or after removal from service because there was no evidence of damage to the electronics or housing in which the vent was installed.

Conclusion

This testing has proven that GORE® Protective Vents maintained excellent airflow and provided the specified water protection over the lifetime of the telecommunication equipment in which they were installed. In cases when the vent's airflow had decreased or the membrane failed the water test, the equipment housing and electronics did not show damage by corrosion or condensation, and the seals were intact. Therefore, the damage to the vents most likely occurred after the equipment was removed from service.

The performance in these tests indicated that the vents maintained its structural integrity for the life of the equipment. Although airflow in some vents was lower than typical airflow specified when new, the measured airflow levels indicated that the membrane was not significantly blocked by contaminants. All of the vents continued to provide sufficient airflow to maintain an internal pressure below the 35 mbar that Gore stipulates for reliable performance.

The testing also showed that the vents maintained their bond integrity throughout the field installation. The screw-in vent membrane stayed firmly attached inside the vent housing, and the adhesive vents remained securely bonded to the equipment enclosure. This indicates that the vents continued to perform reliably even after exposure to challenging environmental conditions such as hail, sand, and rainstorms.

GORE® Protective Vents are engineered to last the lifetime of the equipment in which they are installed. This testing has proved that these venting products meet Gore's commitment to ensure the reliability of the products in which they are installed.



Gore offers a variety of designs, sizes and product forms that are easy to integrate into your outdoor electronic enclosures.

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