GORE® Protective Vents
Case Study



THERMAL CYCLING EFFECTS ON SEALED ENCLOSURES:

Understanding Differential Pressure, Seal Loading, and Condensation Risk

Together, improving life

GORE

The Problem

Fluctuations in temperature can create pressure differentials inside sealed electronic devices. These differentials may be caused by altitude changes, rapid transitions between extreme environments or heat generated by internal components. Repeated heating and cooling cycles cause internal air to expand and contract, leading to pressure build-up and vacuum conditions.

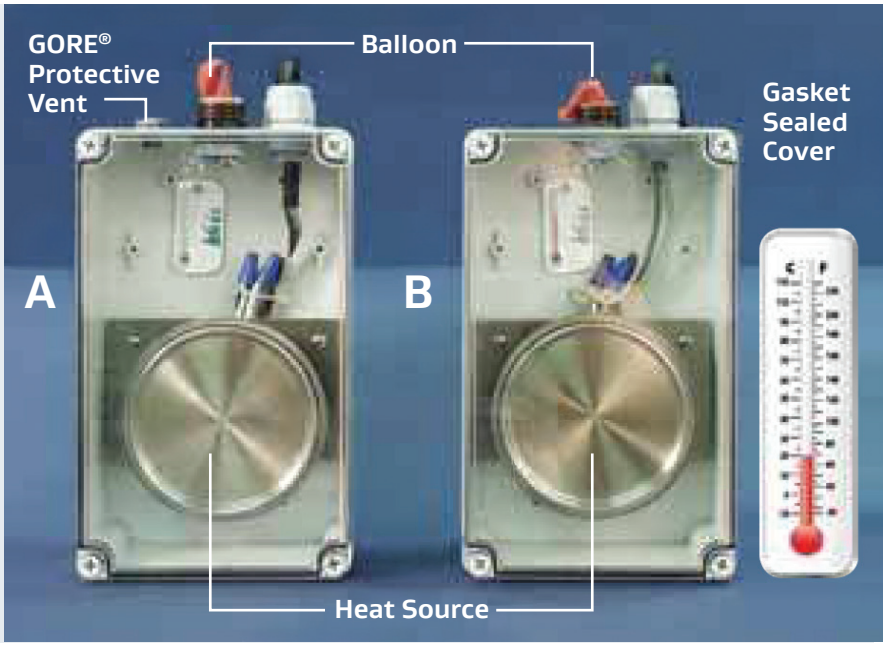
When pressure is not equalized, continuous stress is placed on housing seals. Over time, this stress can degrade seal performance, allowing contaminants such as moisture and dust to enter the device and damage critical components. Pressure-venting solutions, such as GORE® Protective Vents, enable pressure equalization while maintaining a barrier against environmental ingress.

To demonstrate how pressure affects enclosures, Gore simulated rapid heating and cooling cycles under controlled conditions. While these tests reflect real-world use, additional variables should also considered:

- sealed device size
- housing materials
- extreme temperature changes
- altitude fluctuations
- fluid exposure

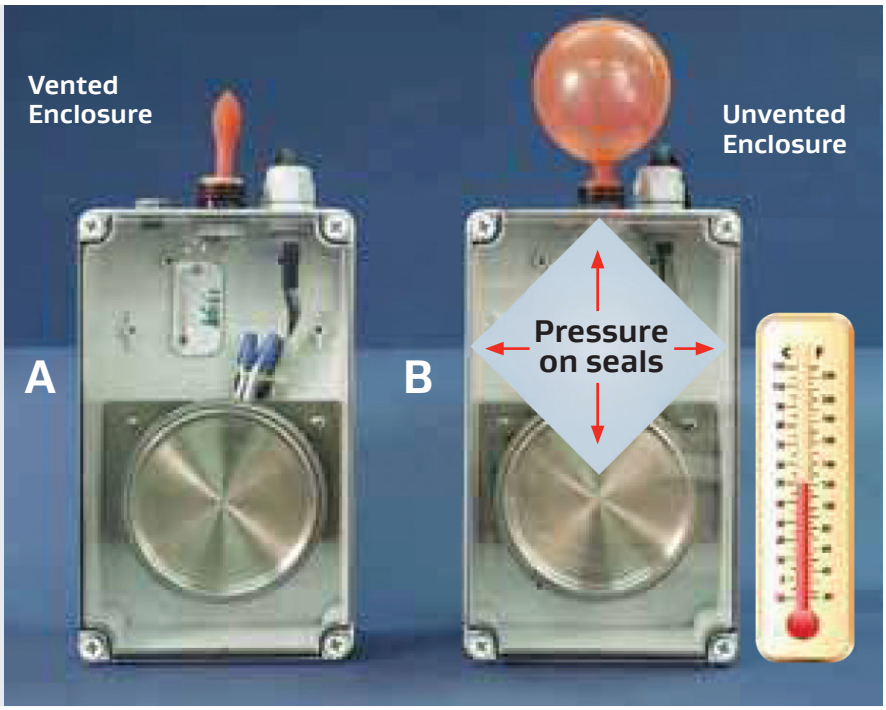
Set-up: Sealed Enclosures in Identical Conditions

Identical enclosures were constructed with a heat source, gasket-sealed cover, and balloon. The balloon was positioned to show the negative and positive pressure differentials caused by the heating and cooling cycles. A GORE® Protective Vent was used for pressure equalization on Enclosure A.



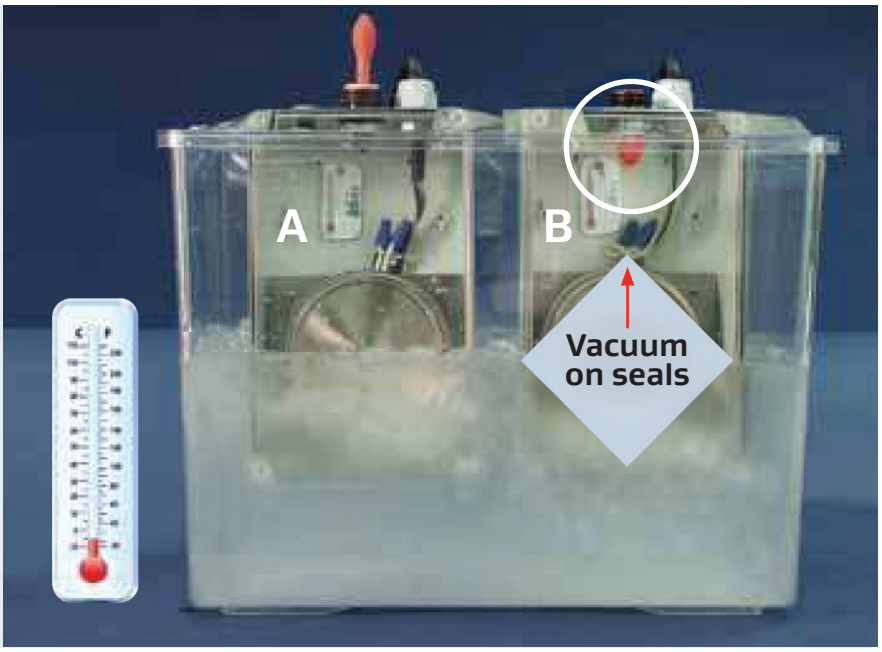
Step 1: Heating Cycle (Simulates Sunny Day)

Both enclosures are exposed to a temperature increase from 20°C (68°F) to 50°C (122°F) in a time frame of 90 seconds (control volume = 4000 cm^3). When heat is applied, the resulting increase in internal pressure within enclosure B causes the balloon to inflate. In contrast, enclosure A maintains stable internal conditions because the GORE® Protective Vent enables air exchange, allowing pressure to equalize with the external environment.



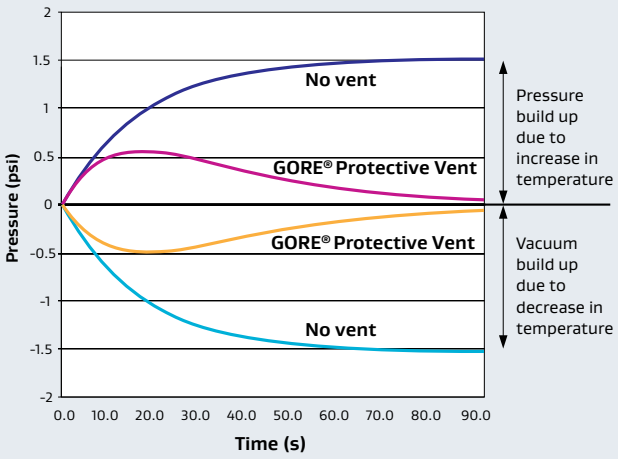
Step 2: Cooling Cycle (Simulates a Rain Shower)

Next, both enclosures are exposed to a 90-second, rapid-cooling cycle from an ambient 20°C (68°F) to -5°C (23°F) (control volume = 4000 cm3). The decreased air pressure in enclosure B creates a significant vacuum, causing the balloon to deflate. Again, enclosure A maintains stable internal conditions, enabled by pressure equalization through the GORE® Protective Vent.



The drastic temperature change causes a vacuum, drawing the balloon into enclosure B. In a real-world situation, contaminants such as liquid, dirt and particles can be drawn into a device, causing failure to internal components.

Minimal Pressure Loading with Vented Enclosures 4000 cm³ enclosure



Solution

Installing a vent in a sealed enclosure allows air to move in and out of the device, reducing the effects of rapid temperature and pressure changes that can create damaging pressure differentials. Protective vents are uniquely designed to equalize internal and external pressure while simultaneously preventing contaminants from entering the enclosure. They use a microporous structure that allows gases to pass but blocks water, dust, and other particulates, helping maintain seal integrity. By supporting continuous pressure balance, these vents also help control internal humidity and reduce condensation caused by temperature cycling and changing environmental conditions, protecting sensitive internal components from moisture-related damage.

These vents are commonly used in applications where equipment is exposed to outdoor or demanding environments, including telecommunications infrastructure, solar energy systems, battery enclosures, energy storage systems, industrial controls, and other outdoor electronic equipment. In these applications, pressure equalization and environmental protection are critical to maintaining long-term reliability and performance.

Versatile Design Options

GORE® Protective Vents are available in a wide variety of sizes and with varied housing materials or adhesive backing. To ensure mechanical fastening, a threaded design was used in the balloon demo simulation. These screw-in vents offer durability for extremely harsh environments and provide quick venting recovery after liquid immersion.



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

About Gore

W. L. Gore & Associates is a global materials science company dedicated to transforming industries and improving lives. Since 1958, Gore has solved complex technical challenges in demanding environments — from outer space to the world's highest peaks to the inner workings of the human body. With approximately 13,000 Associates and a strong, team-oriented culture, Gore generates annual revenues of $5 billion.

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Gore's Performance Solutions Division address complex product and process challenges in a variety of markets, including aerospace & defense, automotive, industrial, electronics, semiconductor and more. By focusing on collaboration and innovation, Gore partners with customers to design their products and processes to be safer, cleaner, more productive, reliable, durable and efficient across a wide range of demanding environments.

Learn more at gore.com/protectivevents.

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PTV-034-R2-STD-EN-JAN26