Under Pressure

Stress-Reducing Tactic for Enclosures

By Gary Chan

Premature failure of telecommunication equipment leads to network downtime, higher costs, increased maintenance and decreased brand loyalty. One of the most significant challenges for this equipment is withstanding the conditions of the environment in which it is installed.

To evaluate equipment performance in these conditions, most manufacturers claim water protection by following the International Electrotechnical Commission (IEC) outlined in ingress protection (IP) protocol IP67 to ensure that the equipment's enclosure can withstand water immersion. They then evaluate temperature stability by using temperature-cycling test protocols such as the IEC 60068-2-1 or the National Equipment Building System General Requirements NEBS GR-63-CORE. If the enclosure does not show any visible damage and functions immediately after exposure to the temperature cycles, it passes the test.

The problem is that these tests do not represent three real-world conditions in which enclosures experience:

- sudden temperature changes that cause significant pressure differentials inside
- external temperature changes and water exposure at the same time
- repeated cycling between hot/cold temperatures and wet/dry conditions

As a result, many manufacturers find that after installation, their equipment does not maintain reliable performance for its expected lifespan even though it had passed the testing protocols for both water immersion and temperature cycling.

Figure 1. Aluminum housing used in testing.

Figure 2. Aluminum housing with ports installed for pressure and temperature probes.

Figure 3. Aluminum housing with GORE® Protective Vent installed.

Venting Their Thoughts

Drawing on their experience with sealed electronic enclosures designed for outdoor applications, W. L. Gore & Associates' engineering team investigated the impact of pressure caused by changing temperatures during these tests. In addition, they included criteria for evaluating the integrity of the enclosure seals during and after the testing.

The team purchased 4 commercially available outdoor housings similar to those used in the telecommunication industry. These 2-liter housings were constructed of aluminum with a silicone gasket, and they were rated to IP67. (Figure 1).

Pressure and temperatures probes were installed in each enclosure (Figure 2), and an M12x1.5 Series Screw-In Vent was installed in 2 of the enclosures to allow pressure to equalize during the testing process. (Figure 3) No electronics were installed inside the housings.

To ensure the integrity of the seals, the bolts were torqued to the manufacturer's recommendation of 8-inch-pounds once the housings had reached a constant temperature of 23 degrees C. In addition, the housings were subjected to a pressure decay test prior to beginning the environmental testing to verify that they were completely sealed.

The team conducted the testing following the IEC 60068-2-1 standard. Once the housings had reached a temperature of 23 degrees C, the boxes were placed in the cooling chamber. The temperature was decreased at a rate of 1 degree C per minute until it reached -55 degrees C, where it remained for 16 hours. The temperature was then increased at a rate of 1 degree C per minute until the enclosure's internal temperature reached and held 23 degrees C for more than 1 hour. This cycle was repeated 4 times, which is in accordance with the standard. Internal pressure and temperatures were recorded every minute.

Pressure Cooker

During the 4 cycles, the vented enclosures experienced virtually no pressure differential, and therefore they maintained the integrity of the seals during and after the testing. (Figure 4).

However, the pressure in the sealed enclosures changed rapidly during each cycle. These pressure differentials were caused by thermal expansion and contraction of air volume as the temperature changed. As the chamber's temperature decreased, the internal air pressure decreased, causing an internal vacuum (< 0 psi). As the temperature increased, the internal pressure

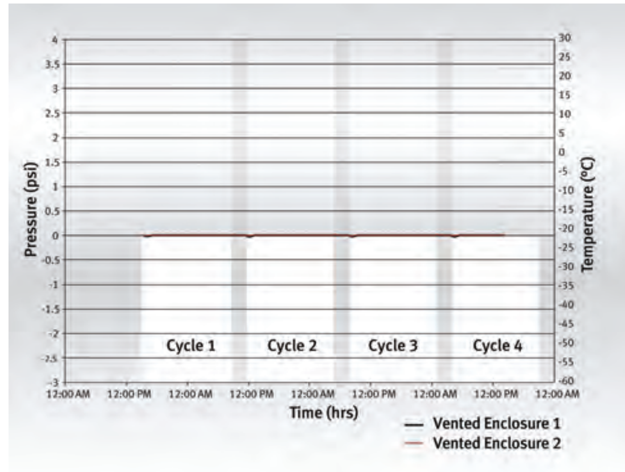

Figure 4. Pressure differentials for vented enclosures.

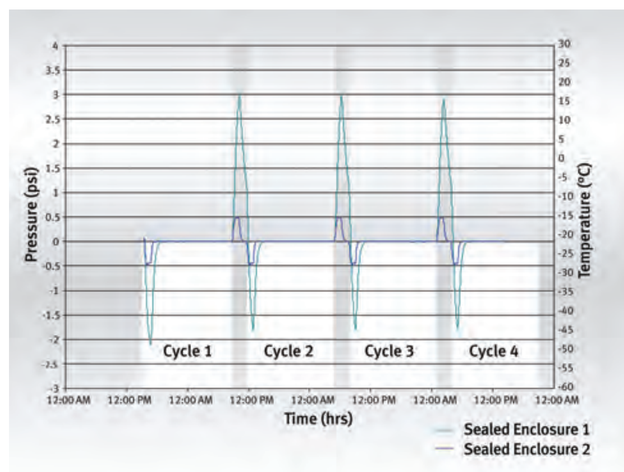

Figure 5. Pressure differentials for sealed enclosures.

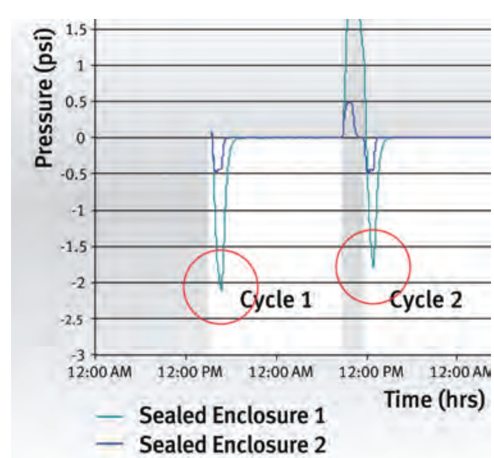

Figure 6. Pressure differentials for first sealed enclosure.

Figure 7. Enclosure visually inspected after the testing.

increased, putting pressure on the enclosure walls and seals. For simplicity, all pressure measurements in this article are gauge pressure.

For example, during the initial cycle at -55 degrees C, the pressure in the first sealed enclosure exceeded -2 pounds/square inch (psi), and the pressure in the second sealed enclosure reached -0.5 psi. (Figure 5) Within 4 hours of the first -55 degrees C cycle, the pressure inside both enclosures returned to 0 psi, which indicates that the pressure had equalized because seal integrity had been compromised. Therefore, a leak path was created.

When the temperature returned to 23 degrees C after the 16 hours at the cold temperature, the pressure inside both sealed enclosures spiked temporarily to 3 psi in the first sealed enclosure and 0.5 in the second sealed enclosure. Again, the pressure had equalized because air was able to move in and out through the leak path created in the initial cold temperature cycle.

In the remaining cycles, the sealed enclosures continued to experience significant pressure differentials. However, because the seal was already compromised during the first cycle, less pressure was required before the enclosure began to draw in air through the leak path. For example, in the first cycle, the first sealed enclosure held its seal until the pressure exceeded -2 psi. In the remaining 3 cycles, the enclosure began to draw in air through the leak path at -1.75 psi to equalize the pressure. (Figure 6).

After the testing, the team followed the IEC 60068-2-1 standard protocol and visually inspected all 4 enclosures. They used a technique to determine potential leak paths by brushing a surfactant solution around the seals of each enclosure after the last cycle of cold temperature was completed. As the enclosures returned to ambient temperature, the internal air expanded, which would cause bubbles to form at any leak paths. For the vented enclosures, no bubbles formed. However, bubbles did form around the gaskets of the sealed enclosures. (Figure 7) In addition, the team opened the enclosures and found no signs of integrity issues or long-term creep behavior with the polymer gaskets.

Pressure Release

Based on the passing criteria of the IEC 60068-2-1 cold temperature test protocol, both of the sealed enclosures would have passed the standard. However, by monitoring pressure throughout the testing, the team determined that the sudden temperature changes caused the internal pressure to reach levels that resulted in compromised seals.

If installed in the field, these enclosures would experience similar pressure differentials and over time begin to draw in moisture and particulates through the resulting leak path, which in turn could damage the electronics inside.

The screw-in vent installed in the 2 vented enclosures maintained a typical airflow of 405 milliliters/minute while providing IP67 water and particulate protection. With this level of airflow, the internal and external pressure remained equalized as the temperature changed, reducing the stress on the seals.

For more than 5 years, Gary Chan has worked with W. L. Gore & Associates' Electronics and Industrial Product Division, most recently as an application engineer for the protective venting team. For more information, email protectivevents@wlgore.com or visit gore.com/protectivevents.