GORE® Acoustic Vents
Design Guide

DESIGNING AN ACOUSTIC SYSTEM WITH GORE® ACOUSTIC VENTS

Together, improving life

Table of contents

Scope and purpose:

This guide explains how the right approach to acoustic design can help you ensure the best possible balance of protection and acoustic performance for your device.

Intended audience:

This guide is offered to acoustic engineers, product designers, and mechanical engineers who are considering a GORE® Acoustic Vent to provide environmental protection and optimize the acoustic performance of their device.

Introduction

Selecting the right acoustic vent for an electronic device requires a balance between the level of protection the vent supplies, and what the vent contributes to the overall sound performance of the acoustic system. This involves balancing requirements within an available design space, optimizing acoustic performance, and ensuring the device is fully protected against every environmental challenge it is likely to face.

The acoustic components, their position, and the spacing of the acoustic vent all affect sound performance. The level of protection depends on the vent (e.g. membrane, stack-up, etc.), and how it interacts with the housing and other components.

This guide explains how the right approach to acoustic design can help you optimize all of these factors to ensure the best possible balance of protection and acoustic performance for your device.

These guidelines focus on acoustic channel design and vent selection. They are intended to help acoustic engineers, product designers, and mechanical engineers to reduce or eliminate any issues that might occur when including acoustic vents in an electronic device.

First, let’s discuss the requirements for the acoustic system as a whole.

Design and functional requirements

An effective acoustic system requires a balance of mechanical, acoustic, environmental, and other requirements.

On the right, we listed some of the requirements that may affect your design.

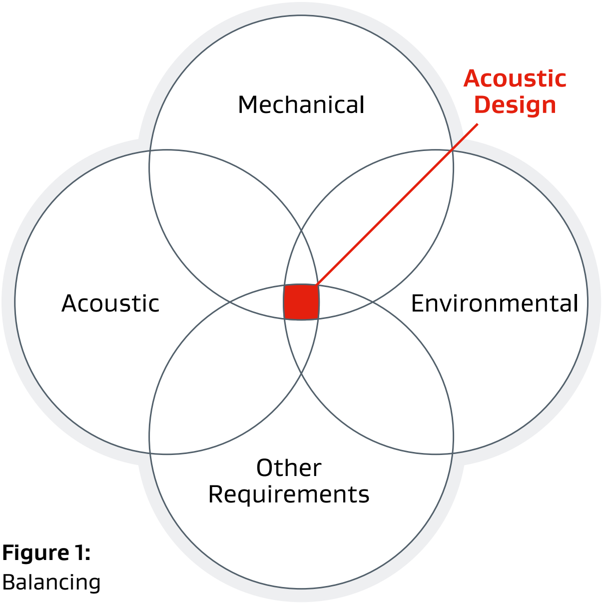


Figure 1: Balancing acoustic system requirements

Mechanical requirements

- Space available
- Mechanical tolerances of the components
- Housing/enclosure material
- Mechanical shock specifications
- Vent location relative to microphone
- Bottom-port or top-port microphone

Acoustic requirements

- Frequency response
- Insertion loss
- Acoustic impedance
- Harmonic distortion
- Acoustic dampening/Attenuation
- Acoustic performance after water challenge
- Part-to-part acoustic consistency

Environmental requirements

- Design requirements for Ingress Protection (dust, splash, or immersion)
- Fluids in the environment
- Ambient temperature range

Other requirements

- Design life and reliability
- Vent installation method
- Threshold requirements established in EU Commission Decision 2005/618/EC amending EU Directive 2002/95/EC (RoHS)
- Cost target
- Development timeline

Typical acoustic system

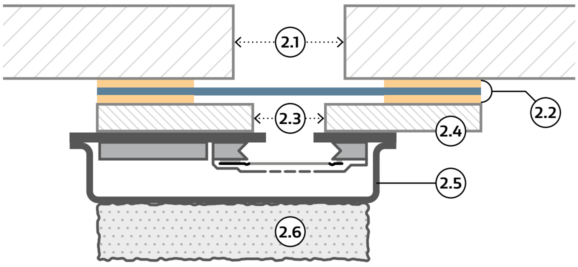
1. Introduction

The performance of an acoustic system ultimately depends on the components selected for the system and how they are integrated.

Within an acoustic system, each component between the external environment and the microphone can shape the overall frequency response. This includes the product housing, acoustic gasket, Printed Circuit Board (PCB), the microphone itself,
and the acoustic vent.

This section explains the function of the components within a typical acoustic system and how they relate to each other.

2. Acoustic System Description and Components



2.1 Front Cavity / Housing
2.2 GORE® Acoustic Vent
2.3 Vent Back Cavity
2.4 PCB
2.5 MEMS Microphone
2.6 Compression foam

Figure 2: Typical acoustic system

2.1. Front Cavity/Housing

The housing refers to the outer shell of the device, which protects sensitive internal components from the external environment. One unprotected area is the acoustic channel leading to the microphone. The size of the acoustic port on the device housing should be as big as possible to improve frequency response, but small enough to protect against the entry of large particles or sharp objects. Typically, it is 1 mm diameter or less.

The vent front cavity connects the acoustic system to the external environment. Sound waves enter the acoustic system through the front cavity, as do potential contaminants such as dust, water, or other pollutants. The depth of the front cavity is determined by the distance between the front of the housing and the vent membrane.

The thickness of the housing cover should be minimized to reduce the size of the vent front cavity.

2.2. GORE® Acoustic Vent

An acoustic vent protects the microphone from damage by contaminants while enabling sound transmission. Because the acoustic path of a MEMS microphone is traditionally open to the external environment, it exposes the microphone to risk of contamination by dirt, debris, or liquids. Without effective protection against these elements, the device will fail.

GORE® Acoustic Vents are engineered to improve device performance by maximizing sound transmission while effectively repelling dust, liquids, and other contaminants. They can be customized in many ways — including size, shape, protection level, mechanical performance and installation options — in order to meet your acoustic system and installation requirements.

Effective vent performance is impacted by decisions made when designing the acoustic system, so it is essential to consider vent selection as early as possible within the design process.

2.3. Vent back cavity

The vent back cavity refers to the space between the acoustic vent and the microphone.

It is important to keep this space as small as possible to minimize insertion loss.

2.4. Printed Circuit Board (PCB)

The bottom-port MEMS microphone (as shown in Figure 2) is soldered to the PCB. A hole in the PCB allows sound to travel to the microphone.

2.5. MEMS Microphone

MEMS microphones are the overwhelming choice for electronic devices, due to their high-quality acoustic performance, cost-effectiveness and extremely small size. Because MEMS microphones are integrated into various locations within a device, the design of their acoustic paths can have a significant effect on the overall performance of the system.

2.6. Compression foam

Gaskets (made of compression foam) and adhesives are used to mechanically seal any gaps that result from different part tolerances. They can also be used to protect against shocks and vibration, and provide a means of compression within the device.

If a gasket is placed in the acoustic channel between the housing and microphone (not shown in the graphic), care must be taken to ensure a good acoustic seal to prevent 'acoustic leaks,' and to help maintain the quality and reliability of the acoustic system.

In more complex acoustic systems, stiffeners, boots and cushions can also be added. Depending on the situation, these require different levels of compression and clamping forces in order to be effective. The clamping force or device compression is a permanent force inherent in the acoustic system within the device. It ensures that the acoustic system remains sealed and that all components are supported during an accidental drop or mechanical shock. The clamping force is necessary to maintain both the environmental and acoustic integrity of the device. To finalize the clamping and compression parameters, a Gore Application Engineer will recommend you do a Design of Experiment (DoE) on your product line.

Acoustic channel design and acoustic performance

1. Protecting the acoustic channel from the environment

Finding the right level of protection for your acoustic channel requires a careful balance of requirements — for acoustic performance and for environmental protection — which tend to be inversely proportional to each other.

Your device's requirements determine which environmental conditions it may be exposed to, which in turn define the IP (Ingress Protection) tests that it must pass. These tests can evaluate exposure to dust, splashes, or immersion. An open aperture or mesh provides unimpeded sound, but offer no protection against dust, liquids, or immersion — hazards that nearly all electronics encounter. Woven mesh offers partial protection from dust, and liquid splash or spray. However, these mesh products are still susceptible to environmental damage or failure.

GORE® Acoustic Vents provide protection for dust, splash, and immersion applications, using a complex, three-dimensional microstructure. The ePTFE (expanded polytetrafluoroethylene) membrane in Gore's immersion vents protects the transducer and the device from dust and liquid immersion up to and including IP68. The highly breathable ePTFE membrane rapidly equalizes pressure in the back cavity, and continuously provides exceptional acoustic performance in all design conditions.

1.1. Dust protection

All Gore ePTFE vents have a rating of IP6x, indicating they are 'dust tight' — meaning they provide complete protection against ingress of particulates. Gore's non-woven vents GAW111 and GAW112 offer a lower level of protection (IP4x) in favor of offering improved acoustic performance.

1.2. Splash protection

Gore has developed splash protection protocols to test for IPx4 compliance under real-world conditions.

The IPx4 test standard typically requires a high-performance vent as well as a housing designed to divert water and help block spray. Instead, Gore has developed a splash test to simulate a single nozzle from an IPx4 test, to help customers understand a venting material's efficiency at preventing water ingress independent of housing design.

1.3. Immersion protection

GORE® Acoustic Vents have been proven to pass the IPx7 immersion test, meaning they maintain durable protection against immersion in one meter of water for 30 minutes. Gore products that can provide protection of up to 5 bar of water pressure are also available.

When testing for the IP68 standard, test methods can be adjusted to meet unique customer requirements, such as deeper immersion levels.

2. Assessing acoustic performance through insertion loss

The difference in the output of a microphone with and without the use of an acoustic vent is commonly referred to as either sensitivity loss or insertion loss. Insertion loss is a key performance metric when assessing the effectiveness of an acoustic vent in relation to the microphone system as a whole. Insertion loss is affected by the size, material and construction of the vent, as well as the cavity design and the type of microphone.

3. How the cavity affects acoustic performance

The performance of an acoustic system is impacted by a range of factors, including cavity dimensions, the microphone design, and the placement of the acoustic vent.

3.1. Cavity volume

Minimizing the cavity volume of the acoustic channel can improve acoustic performance. It not only moves the microphone closer to the housing aperture, but also increases the cavity resonant frequency and minimizes the effect of lossy cavities.

The resonant frequency is also affected by the total length of the acoustic channel, which includes both the front and back cavities. This is an important factor to consider during the design phase, as it becomes extremely difficult to address during later stages of the development process.

Reduce front cavity volume for better acoustic performance

Ideally, any resonant frequency should be as high as possible to reduce the impact on usable audio band. Typically, a resonant peak above 10 kHz is acceptable, provided it is higher than your useable frequency range (some applications may require use at ultrasound frequencies or above the audible range of 20 kHz).

In Figure 3, the left image represents a microphone in a fixture with a minimal cavity. In this case the microphone's frequency response is relatively flat. The resonant frequency (not shown) is above 10 kHz.

The middle image adds a plate with a 5 mm long hole with a 1 mm diameter. A peak is evident at 10 kHz. This is due to a resonance that resulted from changing the cavity's geometry.

The right image increases the hole length from 5 mm to 10mm and the resonant frequency decreases to around 6,000 Hz, reducing the amount of usable audio bandwidth.

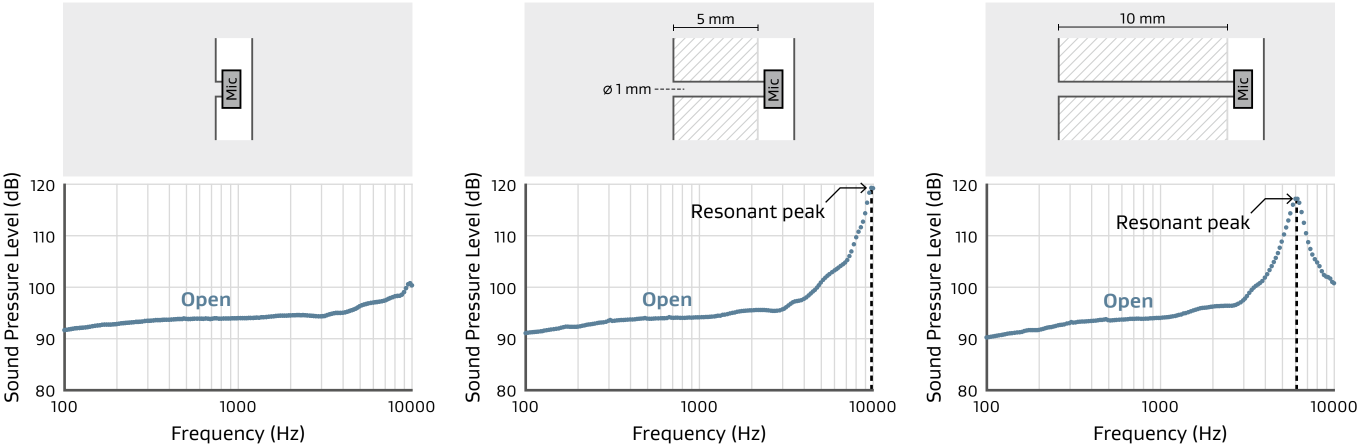


Figure 3: Effect of cavity geometry on resonant frequency (without a vent)

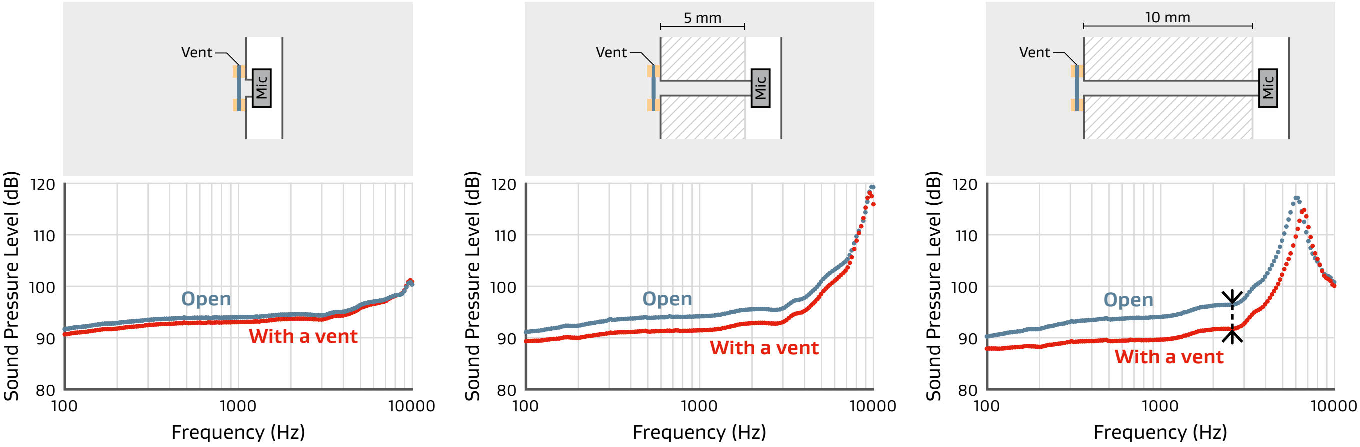


Figure 4 : Effect of back cavity geometry on insertion loss (with a vent)

Figure 4 shows that increasing the length of the back cavity (between the vent and the microphone) will increase insertion loss and lower the resonant frequency.

Reduce back cavity volume for better acoustic performance

The back cavity air volume (between the vent and the microphone) has a noticeable impact on insertion loss. Figure 5 shows that increasing the diameter of the cavity center results in a reduction in resonant frequency (from 6000 Hz to 4000 Hz) and an increase in insertion loss when a vent is applied.

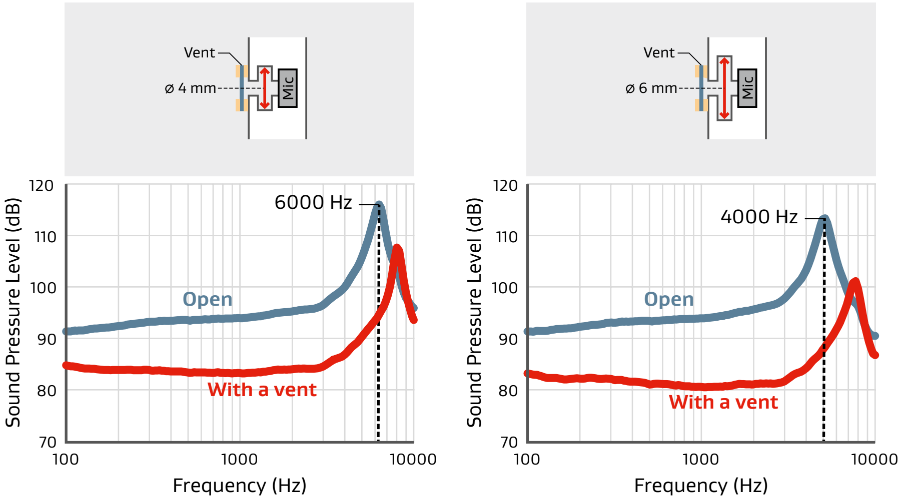


Figure 5: Effect of back cavity volume on resonant frequency and insertion loss

3.2. Placement of the acoustic vent

Figure 6 shows that reducing the back cavity volume, by moving the vent closer to the microphone, significantly reduces insertion loss.

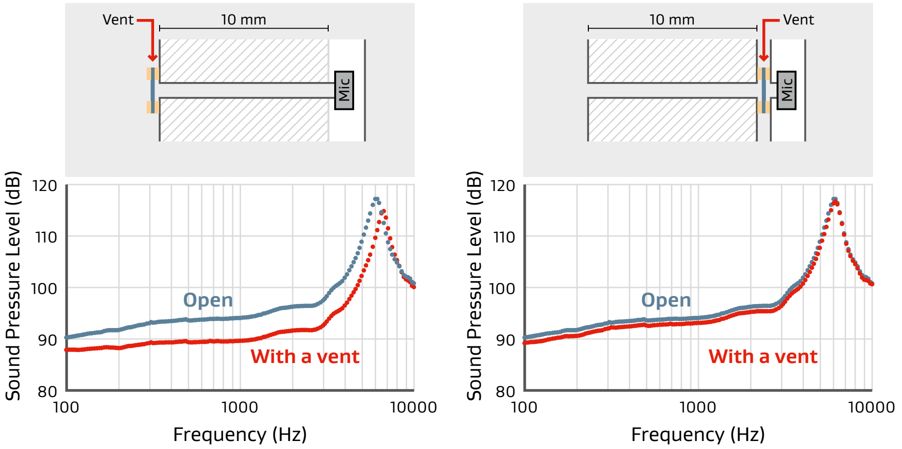


Figure 6: Effect of vent location on insertion loss

4. Effect of water events on acoustic design

Along with the size and shape of the front cavity, the placement of the vent also determines the amount of water that blocks the cavity when the device is submerged — known as water occlusion (Figure 7).

Minimizing the front cavity volume reduces the amount of static water in contact with the vent membrane.

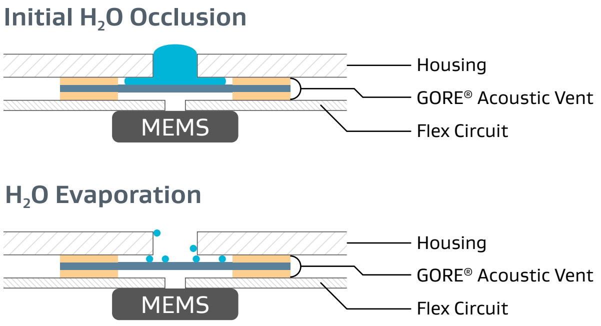


Figure 7: Water occlusion of the vent over time

Reduce front cavity volume to minimize water volume blocking sound transmission

The chart in Figure 8 shows six different sound pressure level measurements that demonstrate how acoustic performance is affected at different times following exposure to water. This includes measurements taken without a vent (black line), with a vent before exposure to water (red line), and at four different times after water exposure.

Immediately after water contact and at one minute, the acoustic performance is essentially the same and shows a resonant peak around 2 kHz, with significantly worse performance at higher frequencies. Frequencies above the resonant peak are essentially unusable or inaudible.

As the water is allowed to drain and evaporate, the mass on the vent is reduced and the resonant peak shifts to the right, as shown by the brown line. This allows for a wider range of usable frequencies.

At about 30 minutes after water contact, the water has completely drained or evaporated, and the acoustic performance does not change any further.

5. Microphone selection recommendation

A bottom-port MEMS microphone is recommended to improve acoustic performance.

Bottom-port microphones typically enable shorter acoustic channels (less air volume) and have lower back cavity volumes (inside the MEMS package). As a result, the bottom-port microphone typically has a resonant above 20 kHz, resulting in a more useable broadband frequency range.

Use bottom-port MEMS microphones

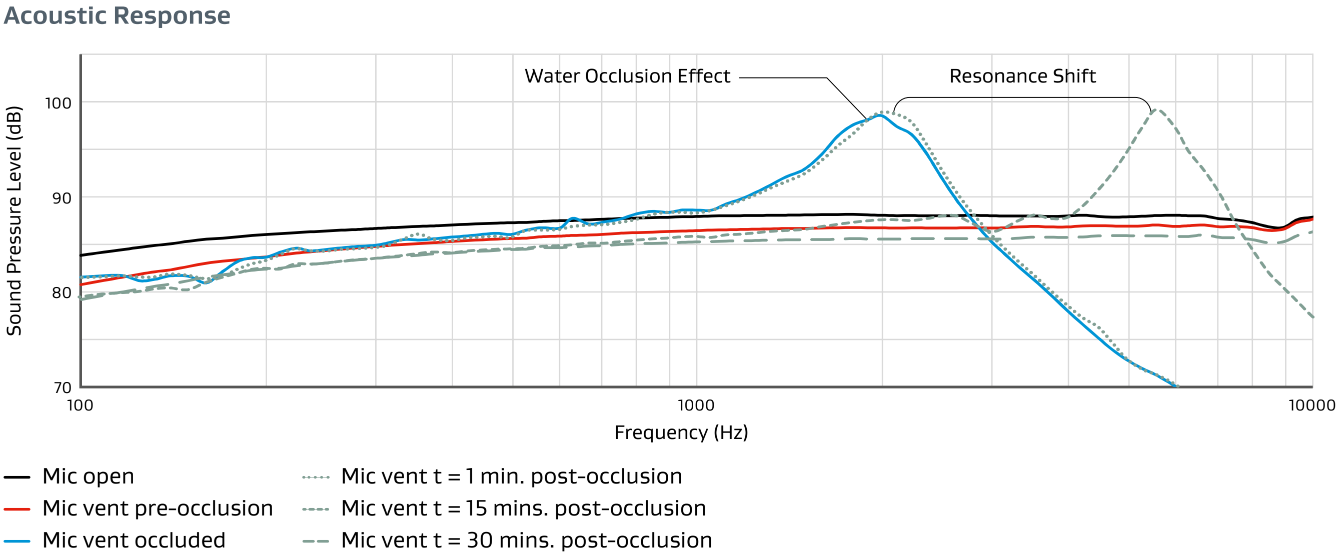


Figure 8: Water occlusion impact on acoustics over time

Vent design

GORE® Acoustic Vents come in standard sizes, stack-ups and prices, to allow manufacturers to quickly select and incorporate the right vent into their design. Our vents are designed to deliver consistent performance, and are suitable for both small-quantity and large-quantity application volumes.

Gore can also create custom vents in virtually any combination of non-standard sizes, shapes, and stack-ups, as well as non-standard and non-commercial materials. Typically, custom parts are best suited (and most economically viable) for large-quantity application volumes. To avoid tooling and engineering fees it may be advantageous to utilize standard parts.

1. Tolerances

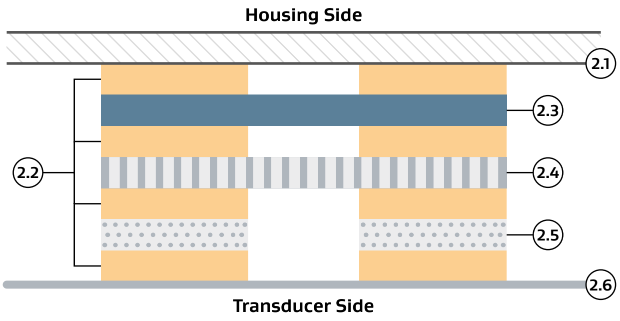
All Gore parts are produced using die-cut process techniques, which include typical levels of tolerance in the vent dimensions. Depending on system requirements, Gore Application Engineers can work with customers to understand and adjust to their tolerance requirements.

2. Typical components of an acoustic vent

The parts, layers and adhesives that make up a vent are referred to collectively as the stack-up geometry. The huge range of possibilities enabled by different stack-up combinations makes it far easier to create the right part for a particular application.

A thinner, stiffer stack-up is generally recommended, as it provides better acoustic performance and more resistance to compression effects. However, sometimes such stack-ups do not comply with a given acoustic design, and may require additional parts or layers, such as cushions, as shown in Figure 9.

Achieving the optimal stack-up geometry is about balancing these trade-offs to ensure the membrane is as close as possible to the microphone while delivering a robust acoustic performance.



2.1 Base liner (handling aid)
2.2 Adhesive
2.3 Membrane
2.4 Stiffener (optional)
2.5 Cushion (optional)
2.6 Pull tab (removed after installation)

Figure 9: Typical acoustic vent stack-up showing multiple layer options

2.1. Base liner

GORE® Vents are provided on a sheet (called a base liner) that allows for easy part removal during installation. Gore has a wide range of available liners, depending on part geometry and adhesive.

2.2. Adhesives

Adhesives are used on each exterior side of the vent to adhere it to adjacent components of the acoustic channel. Adhesives are also used between the interior layers of the vent stack-up.

Most adhesives used by Gore are pressure-sensitive double-sided acrylic, with a variety of center carrier materials that can be used depending on the level of stiffness and thickness required. These carriers can range from a thin polyester film, to a polyolefin or acrylic foam, to a non-woven. Total adhesive thicknesses range from approximately 30 to 400 microns. For acoustic systems with minimal gap tolerances, thinner and stiffer adhesives are preferable, while systems with larger gap tolerances may require an adhesive with a thicker foam carrier.

Standard adhesives are capable of withstanding temperatures of up to 85 °C, which most devices are unlikely to reach. However, adhesives with a wider range of temperature resistance are also available if needed.

The recommended minimum width of an adhesive perimeter is 1 mm; however, depending on design requirements, it is possible to reduce this width to 0.7 mm. The adhesive perimeter is what provides liquid-tight, air-tight and acoustic sealing. As such its width cannot be reduced further without compromising the device's IP rating.

2.3. Membrane

Some of the key factors we consider when selecting the vent membrane for your microphone include:

- The type of application (consumer or industrial)
- The type of microphone
- The required level of protection (against liquids and other contaminants)
- The level of cost and development timeline
- How the microphone is integrated
- The shape and dimension of the acoustic system

Gore has developed and commercialized a number of membranes with precisely-balanced properties, ranging from different strengths and acoustic responses to airflow, ease of installation, durability, and cost.

2.3.1. Oleophobic treatment

ePTFE is naturally hydrophobic and has a surface energy of 18 dynes per centimeter (dyn/cm). This allows it to easily repel fluids with surface tensions above 40 dyn/cm, such as water (72 dyn/cm) and coffee (40 dyn/cm).

Fluids with low surface tensions are more likely to penetrate the membrane, depending on factors such as the fluid's pressure and length of time it is in contact with the membrane.

By modifying ePTFE, it can be made even more hydrophobic. This is sometimes called 'super hydrophobic' or 'oleophobic.' An oleophobic treatment is typically required to effectively repel fluids with surface tensions below 35 dyn/cm. For example: The surface tension of household cleaners range from 27–32 dyn/cm, and 75% isopropanol is 23 dyn/cm.

Use oleophobic treatment to improve contamination resistance

Hydrophobicity and oleophobicity can be expressed by performing an oil-rating test. Materials with higher oil ratings typically can repel lower surface-tension fluids. However, even if two materials have the same oil rating, they may perform very differently in the real world, due to the different oleophobic technologies.

Oleophobicity reduces not only the ingress of liquids but also the wettability of the membrane. If wettability is high, liquids can remain on the membrane and degrade acoustic performance.

2.3.2. Color

ePTFE is naturally white. While some designs may require darker vents to reduce visibility to the consumer, if the vent is not expected to be visible to the consumer, use of a naturally-white membrane is recommended to gain enhanced performance in the acoustic system.

2.4. Stiffener

Stiffeners are distinct, porous PET (polyester) layers within the vent. They can help to reduce sliding or torsion during installation into the device, in addition to reducing movement during compression. They can also provide additional structural integrity, minimizing deflection and deformation of the vent by preventing or reducing compressed energy to the membrane. Furthermore, they can also act as an aid for installation by enabling easier removal of vents from liners.

2.5. Cushion

If an acoustic design features gaps between components, cushions are used to fill those spaces and compensate for variation in tolerances. In addition, cushions help to protect against mechanical shock. When using cushion layers, care must be taken to control gap tolerances to ensure consistent compression levels. Ideally, an acoustic design should not require cushions, as they can lead to performance variation. This occurs because insufficient compression can lead to an acoustic leak, and too much compression can induce tension on the membrane. However, without any cushion filling the cavities, the effects of an acoustic leak can be significant.

2.6. Pull tab

Pull tabs can be a valuable feature — they can protect the vents from particulates and facilitate overall vent handling. Vents with pull tabs are easier to remove from the liner, easier to handle without touching the adhesive, and easier to align during installation. They can also minimize the risk of delamination of the vent.

We recommend the following guidelines when designing Gore custom vents:

- Full pull tabs (Figure 10) and partial pull tabs (Figure 11) should extend 0.2 mm beyond the vent.
- Excessively large pull tabs will increase the vent price. Gore recommends smaller pull tabs when possible. (Figure 12)

A pull tab is an optional feature that can be included in an acoustic vent construction. Including a pull tab should be decided based on your design requirements. If you don't need a pull tab, a temporary top liner will be added to protect the vent.

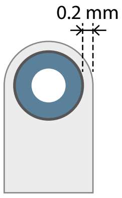


Figure 10

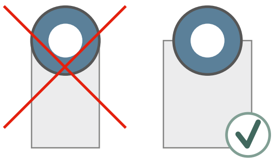


Figure 11

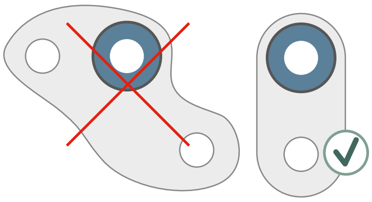


Figure 12

Tradeoffs in acoustic vent parameters

1. Vent geometry

When the vent geometry changes, so does its acoustic performance, even if its active area remains the same size.

For electronic devices, we recommend using circular vents whenever possible. Circular vents deliver predictable vibration of the vent's membrane while maximizing the active area for sound. The active area of a vent is the total area of vent material inside the adhesive perimeter (Figure 13).

Use circular acoustic vents

The acoustic performance of non-circular vents (with dimensions of X by Y) is dependent on the dimensions. For example, the performance of a rectangular vent that is 1 mm x 3 mm is constrained by the shorter (1 mm) dimension and may produce less desirable acoustic performance in comparison with a dimensionally-balanced vent.

Figure 14 shows that insertion loss can be reduced by increasing the membrane active area, which is one of the most impactful variables affecting insertion loss.

Increase active area to improve acoustics

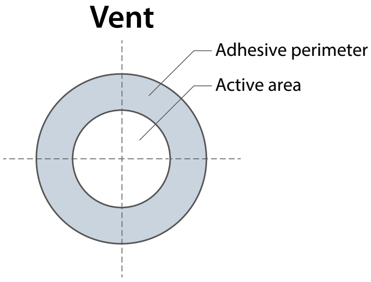
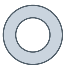
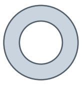
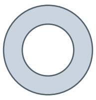


Figure 13: Vent active area

Vent Shape				
Inner Diameter (mm)	1.2	1.6	2.0	2.4
Membrane Active Area (mm^2)	1.1	2.0	3.1	4.5

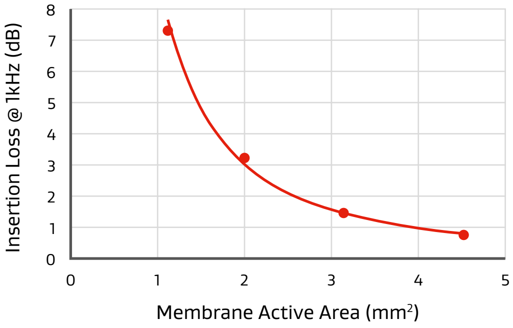
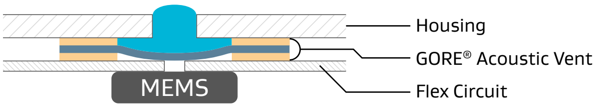


Figure 14: Impact of vent size on insertion loss

When exposed to water entry pressure (WEP), a vent with a smaller active area can reduce the displacement of the membrane. This can positively impact the acoustic performance post-WEP when compared with a larger active area (see Figure 15).

Full H_2O Occlusion with Membrane Deformation

Larger Active Area



Full H_2O Occlusion with Less Membrane Deformation

Smaller Active Area

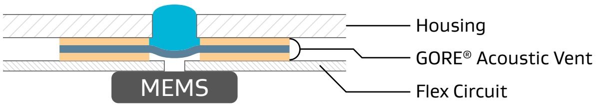
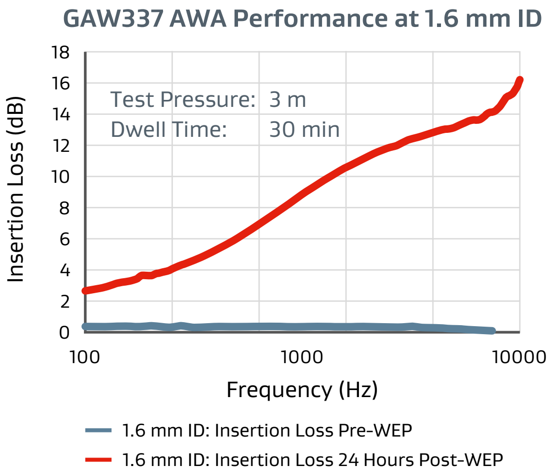


Figure 15: Impact of active area on insertion loss after a water event

To ensure Fitness-for-Use application performance, Gore developed an AWA (Acoustic WEP Acoustic) test which evaluates acoustic performance after WEP exposure. In Figure 16, the top chart shows a vent with a 1.6 mm ID, with the blue line demonstrating low insertion loss before WEP. However, after the water challenge there is an 8 dB increase in insertion loss, as depicted by the red line. This is due to the membrane deforming under stress due to water pressure, leading to degradation in acoustic performance after WEP.

The performance of a smaller 1.0 mm ID vent is shown in the bottom chart. The initial insertion loss is higher, as the smaller ID size means a more rigid vent, affecting the ability of the reactive membrane to vibrate efficiently. However, post-WEP performance is far better, as the membrane deforms less when exposed to water pressure, leading to better recovery post-WEP.

> Reduce active area to improve acoustics after immersion event


GAW337 AWA Performance at 1.6 mm ID

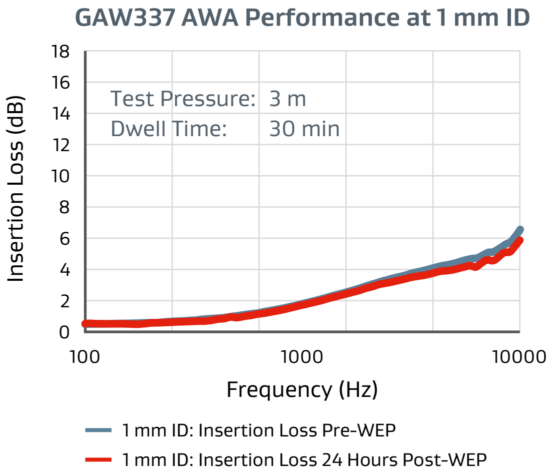

GAW337 AWA Performance at 1 mm ID

Figure 16: Impact of ID size on insertion loss pre- and post-WEP

2. Vent stack-up configuration

To optimize the acoustic performance after a water event, Gore can provide different stack-up solutions.

Stiffener material can be used to minimize deformation during a WEP event (Figure 17). This ‘Super Acoustic’ stack-up can reduce deflection of the membrane (Figure 18). In this design, the stiffener is integrated into the part without being attached to the vent itself. Because it’s not attached, no additional mass or stiffness resides on the vibrating vent; therefore the vent provides lower insertion loss. Conversely, with a traditional laminated or bonded vent, the additional vibrating mass and stiffness on the membrane can increase insertion loss.

A Super Acoustic stack-up is usually recommended for applications where water resistance beyond a depth of 10 m is required. In these instances, an additional stiffener is usually necessary, especially with larger ID vents.

Use ‘Super Acoustic’ stack-up for immersion depths of 10 m or more

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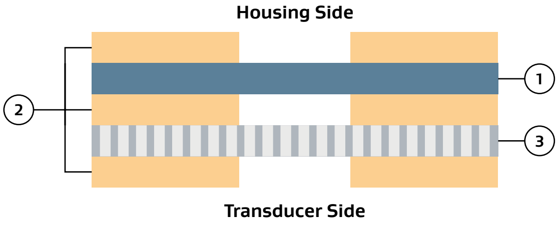
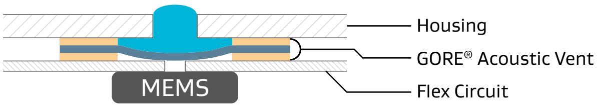


1 Membrane
2 Adhesive (waterproof)
3 Stiffener (mesh or non-woven)

Figure 17: Typical Super Acoustic vent stack-up with a stiffener

Full H_2O Occlusion with Membrane Deformation

Without Stiffener



Full H_2O Occlusion with Membrane Deformation

With Stiffener

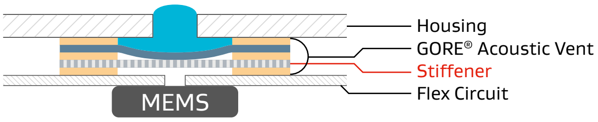


Figure 18: Stiffener reduces membrane deformation

Use stiffener to improve acoustics after immersion event

Vent design process

1. Selecting the right vent

In general, as immersion protection of the electronic device increases, the vent's acoustic performance decreases. It is important to select the vent that combines the right level of immersion protection with the best possible acoustic performance.

GORE® Acoustic Vents offer a range of performance capabilities, to meet varied application needs:

- GAW111, GAW112 and GAW350 offer dust and splash protection, but do not protect against immersion.
- GAW331, GAW344 and GAW346 offer the highest level of WEP protection, but also experience significantly higher insertion loss.
- GAW337, GAW342 and GAW348 offer far better acoustic performance, but provide a lower level of WEP protection.

2. Gore design process

The vents outlined in this chapter have been selected by Gore engineers according to a number of considerations, starting with the level of environmental protection that is required. Figure 19 outlines the product selection process we follow for each application.

All selections based on water protection level

Water Protection Level	Preliminary Material Selection			
	Material	Typical Insertion Loss at 1 kHz		
		1 mm ID	1.6 mm ID	2 mm ID
For Splash Applications (IPx1, IPx2, IPx3, IPx4)	GAW111 45 Rayls	🟢	🟢	🟢
	GAW112 105 Rayls	🟢	🟢	🟢
	GAW350	🟢 0.2	🟢 0.4	🟢 0.0
For Spray Applications (IPx5, IPx6) Requires suitable housing design **For Immersion Applications** (IPx7: 1 m @ 30 min.) (IPx8: 2 m @ 60 min.)	GAW333	🟤 7.3	🟠 1.2	🟢 0.5
	GAW334	🟤 8.0	🟠 1.4	🟢 0.6
	GAW337	🟠 3.0	🟢 0.5	🟢 0.2
	GAW342	🟤 4.2	🟢 0.7	🟢 0.3
	GAW348	🟠 1.0	🟢 0.4	🟢 0.3
For Deep Immersion Applications (IPx8)	GAW344 Up to 50 m @ 10 min.	🟤 12	🟠 2.9	🟠 1.2
	GAW346 Up to 100 m @ 15 min.	N/A	N/A	🟤 3.5

→

Additional Considerations

Thickness (gap)
Compression
Color (white or black)
Oleophobic treatments
Assembly
Pull tabs
Stack-up construction
Volume
Cost

Assumed Conditions:
1. Back Cavity Length of 1 mm
2. Back Cavity Apperture Diameter of 1 mm
3. Insertion Loss measured at 1 kHz

🟤 > 3 dB Loss
🟠 In the range from 1 dB to 3 dB Loss
🟢 < 1 dB Loss

Figure 19: GORE® Acoustic Vent selection process

3. Gore Engineering Support

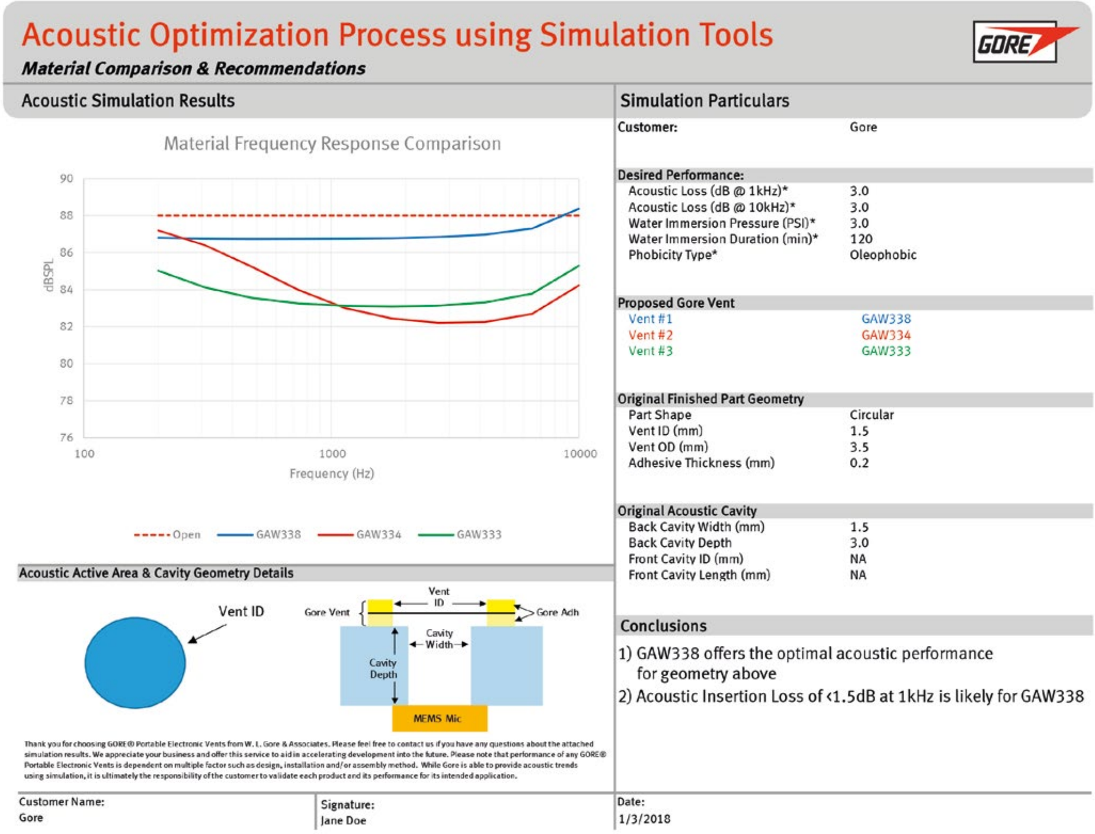
Gore Application Engineers and acoustic experts can provide guidance in assessing the most desirable options and tradeoffs for your acoustic vent. They will study your requirements and employ our advanced acoustic modeling technology to make recommendations specific to your product needs. Our modeling simulations can show variations in acoustic performance as a function of vent membrane type, vent size, and/or back cavity design (example in Figure 20). Gore engineers will model multiple vent membranes, sizes, and cavity designs for your application, quickly identifying the trade-offs in your design and potentially saving build/testing resources and time.

Leverage Gore Application Engineer knowledge and support

Gore's acoustic modeling service ensures that manufacturers receive:

- Rapid feedback on their acoustic system's performance
- Selection of the right membrane for the application and predicted acoustic performance in the acoustic system
- Optimized performance through recommended changes to acoustic system design
- A better understanding of which system modifications are critical to ensure ideal acoustic performance
- Gore can also provide Complex Acoustic Transfer Impedance simulations and data to customers with OEM acoustic models.

Once the membrane material and size are selected, Gore Application Engineers will complete the design including the appropriate stack-up, a part presentation and an offer of initial samples for testing.



Acoustic Optimization Process using Simulation Tools

Material Comparison & Recommendations

Acoustic Simulation Results

Acoustic Active Area & Cavity Geometry Details

Thank you for choosing GORE® Portable Electronic Vents from W. L. Gore & Associates. Please feel free to contact us if you have any questions about the attached simulation results. We appreciate your business and offer this service to aid in accelerating development into the future. Please note that performance of any GORE® Portable Electronic Vents is dependent on multiple factor such as design, installation and/or assembly method. While Gore is able to provide acoustic trends using simulation, it is ultimately the responsibility of the customer to validate each product and its performance for its intended application.

Simulation Particulars

Customer:	Gore
Desired Performance:	
Acoustic Loss (dB @ 1kHz)*	3.0
Acoustic Loss (dB @ 10kHz)*	3.0
Water Immersion Pressure (PSI)*	3.0
Water Immersion Duration (min)*	120
Phobicity Type*	Oleophobic
Proposed Gore Vent	
Vent #1	GAW338
Vent #2	GAW334
Vent #3	GAW333
Original Finished Part Geometry	
Part Shape	Circular
Vent ID (mm)	1.5
Vent OD (mm)	3.5
Adhesive Thickness (mm)	0.2
Original Acoustic Cavity	
Back Cavity Width (mm)	1.5
Back Cavity Depth	3.0
Front Cavity ID (mm)	NA
Front Cavity Length (mm)	NA

Conclusions

1) GAW338 offers the optimal acoustic performance for geometry above
2) Acoustic Insertion Loss of ‹1.5dB at 1kHz is likely for GAW338

Customer Name: Gore	Signature: Jane Doe	Date: 1/3/2018

Figure 20: Acoustic Modeling Materials Comparison Report

Installation and handling considerations

1. Manual or Automated Installation

GORE® Acoustic Vents are delivered ready to be installed. They are most commonly supplied on discrete sheets for manual installation. These vents can be designed with or without pull-tabs to enable easier alignment when placing them on the device.

If the manufacturer has fully-automated installation capabilities, the vents can be supplied on continuous rolls compatible with a high-speed pick-and-place machine. The rolls can be supplied 'one-up' – meaning vents are in a single sequential row to allow for ease of indexing for the machine.

2. Alignment features for manual installation

Use alignment features

Accurate placement of the vent onto the device is critical to acoustic performance. In order to ensure the vent is aligned properly, alignment features are typically recommended for all vents with an ID of less than 1.5 mm. These features can consist of a pin, a recess, an edge or a corner that aligns with the pull-tab to ensure accurate placement. Figure 12 (page 13) shows a pull tab with a through-hole for an alignment pin.

3. Impact of shear/torsion

For optimal vent performance, the installation process should not introduce any torsional or shear forces, as these are likely to degrade both acoustic performance and environmental protection.

4. Installation compression and device compression

GORE® Acoustic Vents are subject to compression resulting from both the installation process and from continuous device compression. We always recommend that you consult with Gore Application Engineers regarding compression force. In some cases, the Application Engineer will need to conduct compression studies on designs to establish the impact of compression force on acoustic performance.

4.1. Initial installation compression

Use proper installation process and installation force

Installation compression is temporary and occurs when the vents are applied to the housing or PCB.

Vents are applied using pressure-sensitive adhesives (PSA), and Gore recommends applying installation pressures of 5-10 Newtons for 5–10 seconds. This will activate the PSA and ensure a good, uniform, leak-free bond to the housing or PCB.

Over-compression could lead to permanent damage to the vent. In general, higher amounts of compression can lead to higher insertion loss and greater acoustic variability. After installation, it's critical to allow the vent to "set" before testing or using it, in order to ensure adequate adhesion cure time with the housing.

4.2. Continuous device compression

In-device compression is a permanent force and occurs once the assembly is attached to the housing. It can be the result of screws or clamps holding components in place after assembly. The higher the IP rating of a device, the more critical it becomes for in-device compression to ensure good acoustic and water seals.

Uneven or inadequate amounts of compression can result in acoustic or water leaks through the stack-up, especially if it has a foam layer. Inadequate compression can also lead to failure of the vent over time, caused by layers separating from each other.

Use recommended device compression force

Conversely, too much compression can result in membrane wrinkling, oozing of adhesive or foam into the vent's active area, and the sliding of layers within the stack-up. This can result in increased acoustic variability and transmission loss, as well as decreased WEP and airflow performance.

Gore recommends the continuous device compression force to be in the same range as for the installation compression: 5–10 Newtons.

5. Typical device compression methods

Device compression can be provided by the vent or by materials supplied by the manufacturer such as foam or rubber boots which are incorporated into the design. Gore makes vents with a micro-cellular polyurethane foam layer incorporated in the stack-up. These foams typically range in thickness from 0.2–0.7 mm. Although Gore has a variety of adhesives that have foam-based center carriers, these provide a very small amount of compressibility and should not be relied on for significant amounts of compression.

When the vent is compressed against the housing, Gore's guidelines recommend that the foam layer itself (not the entire vent thickness) should be compressed by 25–40%. This compression ratio may vary depending on the foam type and part construction. For example, if you use 0.4 mm thick foam, the entire vent should be compressed by 0.1 mm to 0.16 mm (25% to 40% of 0.4 mm), regardless of the total thickness of the vent. Please consult with your Application Engineer for specific recommendations.

6. Compression versus immersion levels

For immersion levels of just one or two meters, in-use device compression is not always required, although care must be taken to ensure a good acoustic seal between the vent and PCB to ensure no acoustic leakages exist. This can be accomplished with a properly designed GORE® Vent using either adhesive or gasket-based components.

However, for deeper immersion levels of three meters or more (and especially at higher pressures), it is necessary to have device compression or risk adhesive failure. In these cases, manufacturers should consult their Application Engineer to establish the correct level of mechanical compression.

Design recommendations with GORE® Acoustic Vents

In this design guide, we explained how to effectively optimize mechanical, acoustic, environmental and other requirements to ensure the best possible balance of protection and acoustic performance for your device.

Here is a summary of the important design recommendations with GORE® Acoustic Vents:

- Reduce front cavity volume for better acoustic performance
- Reduce back cavity volume for better acoustic performance
- Reduce front cavity volume to minimize water volume blocking sound transmission
- Use bottom-port MEMS microphones
- Use oleophobic treatment to improve contamination resistance
- Use circular acoustic vents
- Increase active area to improve acoustics
- Reduce active area to improve acoustics after immersion event
- Use ‘Super Acoustic’ stack-up for immersion depths of 10 m or more
- Use stiffener to improve acoustics after immersion event
- Leverage Gore Application Engineer knowledge and support
- Use alignment features
- Use proper installation process and installation force
- Use recommended device compression force

Why Choose GORE® Portable Electronic Vents for Your Electronic Devices?

Leading OEMs have specified over 10 billions of GORE® Portable Electronic Vents because they know our products and services can help accelerate their development of innovative and differentiated devices in fast-paced, highly competitive markets.

Product & Application Leadership

Grounded in a deep understanding of material science and acoustics, Gore can provide the optimum venting solution. We balance trade-offs between diverse problems such as adverse operating environments, immersion events and acoustic performance.

Fast Development

The mobile electronics industry develops and releases new products quickly. Our fast response to customer requests during the development process sets us apart. Gore supports this need for quickness with designs and prototypes to ensure engineering teams can meet their project timelines and their application requirements.

Material Science

Gore is a global materials science company dedicated to transforming industries and improving lives. Gore develops materials with microporous structures that provide desirable attributes and performance characteristics to engineer vents and other products used in a variety of markets and industries.

Reliable Performance

To ensure products are “fit for use”, every Gore product must adhere to the highest standards of quality, performance and reliability. Through a comprehensive understanding of end-use applications and requirements, our products do what they say they will do.

Supply Security

Leading OEMS specify Gore because we have consistently proven our ability to quickly ramp up to supply vents for projects of over 10 million devices per year and to continue to supply high quality products on-time without disruption.

Global Support

Our global teams of sales associates, application engineers, manufacturing engineers, and research personnel enable us to provide agile and robust support to customers around the world.

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 more than 13,000 Associates and a strong, team-oriented culture, Gore generates annual revenues of $4.8 billion.

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◁ Index ▷