DRY RUN

Through its invention of GORE-TEX® fabric, Gore has become synonymous with waterproof clothing. Today, the company plays an equally vital role keeping our phones dry.

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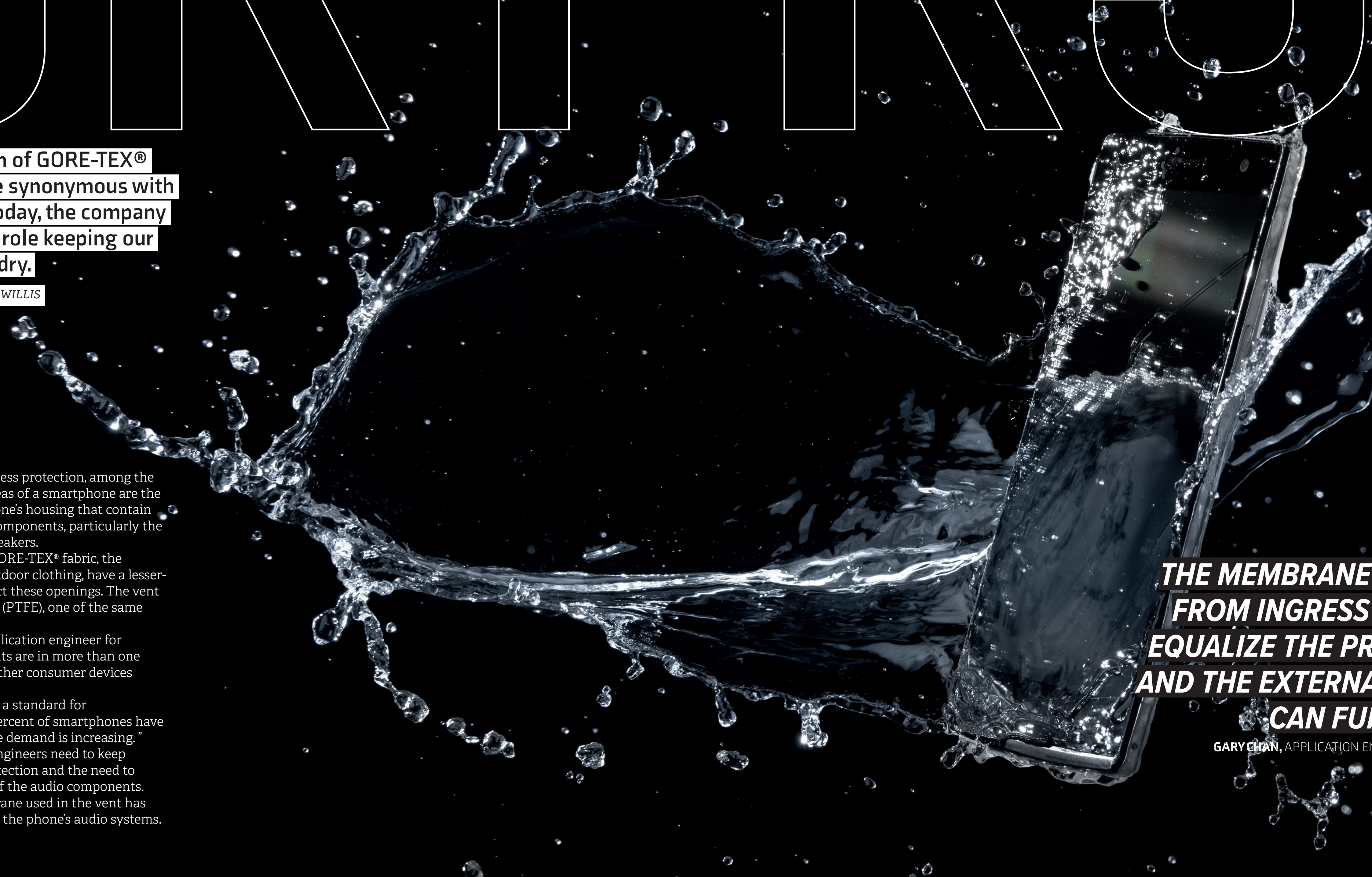

When it comes to ingress protection, among the most vulnerable areas of a smartphone are the openings in the phone's housing that contain the device's audio components, particularly the microphone and speakers.

Gore, the company that invented GORE-TEX® fabric, the waterproof material used in much outdoor clothing, have a lesser-known role developing vents to protect these openings. The vent is made from polytetrafluoroethylene (PTFE), one of the same materials used in GORE-TEX® fabric.

According to Gary Chan, a Gore application engineer for portable electronic venting, Gore's vents are in more than one billion smartphones, wearables, and other consumer devices around the world.

"In the past waterproofing was not a standard for smartphones," says Chan. "Today, 37 percent of smartphones have some level of water protection and the demand is increasing."

When developing the vent, Gore's engineers need to keep in mind both the need for ingress protection and the need to safeguard the acoustic performance of the audio components. For this reason, says Chan, the membrane used in the vent has "acoustic properties" that compliment the phone's audio systems.

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THE MEMBRANE CAN PROTECT THE DEVICE FROM INGRESS BUT, IN ADDITION, IT CAN EQUALIZE THE PRESSURE INSIDE THE DEVICE AND THE EXTERNAL ENVIRONMENT SO THAT IT CAN FUNCTION PROPERLY

GARY CHAN, APPLICATION ENGINEER FOR PORTABLE ELECTRONIC VENTING, GORE

Left: Acoustic testing inside Gore's anechoic chamber

SAFEGUARDING ACOUSTIC PERFORMANCE

One way in which the membrane does this is by equalizing pressure inside the device. Chan explains: "In order for a device to receive and release sound, vibration of the microphone diaphragm and speaker diaphragm has to happen. But a build-up of pressure inside the device will affect these vibrations, and that will affect the receiving and releasing of sound waves.

"The membrane can protect the device from ingress but, in addition, it can equalize the pressure inside the device and the external environment so that it can function properly."

During development the vent is treated with chemicals and laminated with different sorts of adhesives, says Chan. Typically, the vent is custom-made to fit the demands of the specific device, he says.

As part of the development process, Gore rigorously tests the effectiveness of the vent both for ingress protection and audio performance. Chan says: "At the end of the day, the material has to survive the testing, but also it has to perform."

In most cases the vent is tested separately from the phone. "Over the years we have developed enough of an understanding of our products and the end use, that usually we can just test our product using a test setup that simulates the device," says Chan.

However, in cases where the smartphone design is either "very unique or the design has a lot to do in terms of ingress protection and acoustic performance," then the vent will be tested after it has been fitted to the phone.

When testing, Chan and his team meet standards set down by the International Electrotechnical Commission (IEC). In the case of ingress protection the most relevant standard is IEC 60529, which provides criteria for validating a device's protection against contaminants.

UNIQUE CHALLENGES OF SMARTPHONES

But according to Chan, IEC 60529, which was originally developed for the testing of industrial electronics in industries such as construction and transportation, does not address the "unique challenges" posed by today's smartphones.

For this reason Gore has developed its own testing methodology that adheres to the IEC standard as well as directly addressing the real-world conditions that these devices encounter. "In our test lab we can perform more than 20 different kinds of tests in order to meet the unique requirements of different customers," he says.

Often, he says, a series of tests are performed to determine

WHY MAKING SMARTPHONES MORE RELIABLE COULD MAKE THEM HARDER TO REPAIR

Durability and possible future repair of smartphones should be thought of from the product's initial design, ***write Mauro Cordella and Felice Alfieri, of the European Commission's Joint Research Centre (JRC)***.

From an engineering perspective, durability can be pursued by improving the reliability of products (i.e. reducing the likelihood of failures) and/or its repairability (i.e. facilitating its restoring in case of failure).

In the last few years, the European Commission has set out, under the Ecodesign Directive framework, minimum legal requirements to enhance the reliability and facilitate repair and reuse of a broad set of electrical and electronic equipment.

In this context, JRC scientists alongside researchers from the Fraunhofer Institute IZM in Germany have applied their competences in this field to analyze what could be done from a technical point of view to make more durable smartphones.

The results of this research, published last year in the *Journal of Cleaner Production*, provide an evidence base that can support designers, consumers and regulators in taking more informed decisions about the manufacture, purchase, use and re-use of smartphone devices.

Behavioural and technical reasons leading to malfunctioning and premature replacement of devices were first investigated in the study, based on best available information from the scientific literature, consumer's organization surveys and statistics from repairers.

Most common technical issues identified include: battery loss of performance due to aging, display damages due to dropping on a hard surface, and contact with water and dust.

To some extent, smartphones can be designed to withstand different types of stresses and aging processes. Manufacturers and consumer organisations apply standardized tests methods to measure the resistance of devices to such stresses. Reliability tests currently applied to smartphones include for example: drop tests; display scratch resistance tests; ingress protection (waterproof and dustproof tests); and battery endurance testing.

But design-for-reliability is not the only strategy available to extend the lifetime. Once a failure occurs, it is important to make repairs as easy as possible. Several technical aspects can hinder or facilitate the repair of smartphones and, by extension, their reuse.

The first is the lack of spare parts and software/firmware updates, as well as their relative costs. According to the price lists available on the manufacturer's websites, repairing the display could cost up to 15–40 percent of the purchase price of new devices.

Another important aspect is the sharing (via the web, for example) of maintenance and repair information. While some manufactures are increasing the amount of repair information shared, some key information is often still restricted to a subset of professional and/or authorized repairers because of safety, liability and/or confidentiality issues.

Thirdly, currently a technical and economic barrier to repair is the difficulty to disassemble and reassemble parts of smartphones (in particular batteries and displays).

In the second part of this study, a broad sample of products on the market was analyzed, which highlighted a trend towards increased use of adhesives generally making the disassembly of parts more difficult. For example, in the case of the display, the entire unit usually must be replaced since the individual components are fused together and come as one part.

Enhancing the reliability and the repairability of smartphone do not always go hand in hand. In fact, improving one strategy could lead to potential conflicts for the other. This can be the case when complying with high waterproof and dustproof performance requirements (e.g. IP67 or IP68) where the need for additional use of adhesives make it harder to replace the display or the battery in case of failure.

However, it should be possible to find a satisfactory balance between the two strategies.

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> **GARY CHAN,** APPLICATION ENGINEER FOR PORTABLE ELECTRONIC VENTING, GORE

how the vent performs under different variables. He says: "For example, what happens when the device is exposed to dust. Can it still pass the water protection testing?"

Another question they might need to answer is: how is the vent's reliability impacted by temperature and humidity exposure? To simulate this, temperature and humidity chambers are used. Afterwards, Chan and his team can test the device inside an anechoic chamber to see how the exposure has impacted its acoustic performance.

According to the criteria of IEC 60529, venting systems like Gore's are tested as a component of the assembled device and, as such, do not need to be independently rated. Their performance does not need to be evaluated until the device is assembled.

However, Gore prefers to tests its membranes throughout the development stage "to make sure that they can truly provide ingress protection," says Chan.

"Then we do the final product testing: meaning that after we have processed and cut the part to size, we install it on to a cast plate where we simulate the real-life use cases and test for the IEC standard."

Above: Gore's vents are in more than one billion smartphones and other consumer devices

WATERPROOF TESTING

To test for waterproofing, Gore carries out spray testing and immersion testing. The spray test assesses both the amount of time needed for water to penetrate the vent and the amount and speed at which water passes through the material during the test.

For the shallow immersion test, IEC 60529 requires that the product undergo full submersion in one meter of water for 30 minutes. However, in real-life most instances of shallow immersion with a smartphone occur when the device is dropped into water, either in a sink at home or a puddle in the street.

This kind of action creates a pressure on the device as it hits the water. Since the IEC standard doesn't address this kind of real-life scenario, Gore has developed a test protocol of its own for shallow immersion that takes into account the pressure exerted onto the device when it is dropped into water.

Water is not the only thing that the acoustic vent is meant to protect against. Microscopic particles of solid or liquid matter suspended in the air, known as particulates, can also damage the smartphone's internal components if they are allowed to penetrate inside.

Under the IEC standard, materials are tested on their capacity to block particulates of 75 microns (μm) or larger. However, according to Gore's own literature on the subject, smartphones are exposed to much smaller particulates, such as human hair, carpet fibers, and smoke fumes, that are often no more than 30 μm in size.

MESSINESS OF REAL-LIFE USE CASES

To address this discrepancy, Gore's engineers have developed a testing protocol that focuses on particulates that are as small as five microns. They also test particulates in combination with other materials, in order to simulate "the messy real-life environment" that smartphones are exposed to.

Chan says: "On our bodies we have oil, we have sweat; we might have soapy water. So we might mix any of these to simulate what will happen to the membrane after being exposed to those environments."

The type of testing they do with the particulates depends on what they are trying to find out, he says.

"So after the exposure, we can do liquid testing, we can do immersion or spray testing, and we can perform acoustic testing."

If there has been any point of failure on the membrane state-of-the-art testing techniques like Scanning Electron Microscopy (SEM) or Energy Dispersive X-Ray analysis (EDX) can be used to determine exactly how the vent was penetrated.

In the case of water ingress, however, a visual examination is usually all that is needed. "Once there is a breakthrough, the water tends to show on the other side pretty rapidly," says Chan. **CET&D**