SoundBites Podcast Transcript
Episode: Waterproof Hearing Aids featuring Brian Dahl

Dr. Dave Fabry:
Welcome to Starkey Sound Bites. I'm Dave Fabry, Starkey's Chief Innovation Officer and your host. It's summer in Minnesota, the land of 10,000 lakes, and that means that it's pool time and lake time. With that, for many hearing aid users can come the inconvenience of jumping into the pool or the shower or a lake, and this often in the past has meant bad news for the durability of their hearing aids. But fortunately, we have some good news in this regard. And that's the topic of today's podcast. With me, our guest is Brian Dahl, who's an expert on this topic among others in his role as Vice President of Quality and Regulatory at Starkey. Brian, it's a pleasure to have you on today.

Brian Dahl:
Thanks, Dave. Glad to be here.

Dr. Dave Fabry:
So let's dive right into the deep end on this and talk a little bit about moisture and why is this such a big deal for hearing aid wearers?

Brian Dahl:
So it's interesting. Waterproof, moisture, that problem has been around ever since the beginning of hearing aids. And as a bit of a historical fact, if you want to dive into that a little bit, ever since the first transistor was used in hearing aids, so the Shockley semiconductor, those were plagued by moisture and heat. So in the early fifties when transistors were now the next big technology, the Zenith Corporation introduced transistors and given their construction and sensitive electronics, they were failing at a high rate. And so that had to be solved. And so they solved it through different packaging or different sealant methodologies. So that was just a single germanium transistor. Now, fast-forward about a decade or so when Kilby and Noyce invented the integrated circuit, so further miniaturizing the electronics, those too had moisture problems. And what we see over time is that with miniaturization, sensitive electronics now become more sensitive and problems reemerge with themselves. So it's been a problem ever since the fifties and the early beginnings of hearing aids.

Dr. Dave Fabry:
You could argue even before that. I mean I would argue, as a Wisconsinite, many good things have Wisconsin in them. And Kilby, after graduating from the University of Illinois in Champaign, Urbana, got his first job after college at Central Labs in Milwaukee and started working on miniaturization really in 1947. So I'd say it even goes back a decade prior to when he and Noyce, then of Fairchild and later of Texas Instruments, developed the first integrated circuit. But what they discovered, and really what Kilby had as a personal interest was trying to work on miniaturization while improving the durability. So I mean, in many cases, personal experience, Kilby had a hearing loss and ultimately contributed with Central Labs in Milwaukee, Wisconsin to the first transistor hearing aid, and then later that was, of course, improved on in many ways, as you say.

Brian Dahl:
Right. And it's an interesting problem too, because you have to ask the question, "Why miniaturize?"

Dr. Dave Fabry:
Yeah.

Brian Dahl:
"Why is it important to do so?" And hearing loss by its nature is invisible. So the addition of a device now makes an invisible condition visible. So there's this inherent desire from our patients to make it smaller, to make it not seeable by others. The other thing is by having it miniature, it provides you different benefits, so you use less power. Now we could think of two scenarios. We could think of our new Genesis, which is very, very low power consumption compared to a old tube amp hearing aid, which used to be the size of a refrigerator. Very different power profile. So it isn't just make it smaller, it's make it more efficient, you use that limited power in better ways.
So in a way, when we think of the moisture problem, as we will call it right now, it's been there forever. And we usually see it reemerge when we reach a new plateau of new technology. So then that brings us to lithium ions. So five years to about a decade ago, that's when we started to see the emergence of those lithium ion batteries in hearing aids. You reach now a new plateau where what was once okay, is now no longer given the new factors and given the convergence of those technologies.

Dr. Dave Fabry:
Indeed, and that rechargeability that you mentioned, you said zinc-air was sort of the commonplace battery after the early days, back in the twenties and thirties when carbon batteries were used. In combination with transistors and integrated circuits, zinc-air really became known as the safe battery because it's relatively impervious to anything really bad that can happen if those batteries get wet. Lithium ion, as you say, changes the bar in terms of rechargeability. And now as you mentioned, with Genesis, we're able to deliver between 40 and 50 hours depending upon the style of battery life, but we do need to ensure that those batteries stay dry.

Brian Dahl:
Right. And that's a really good comparison, zinc-air to lithium ion. With zinc-air, you had an opening so there was always a pathway for what through-

Dr. Dave Fabry:
Had to be in order to be powered.

Brian Dahl:
Had to be.

Dr. Dave Fabry:
Yeah.

Brian Dahl:
And also if something went wrong, you could just throw away the battery. So you were disguising problems through a consumer behavior. But with lithium ion, we can now start to enclose the device better and make it extra protected against moisture. And you brought up Genesis. So our new Genesis product, we've added multiple different layers to keep that lithium ion, the circuitry, and everything as dry as possible because if we keep that safe and dry, then the device will last 51 hours every day throughout the life of the device.

Dr. Dave Fabry:
In the summers of Minnesota as well as the winters and the summers in Miami and in New Orleans and places where there's high humidity.

Brian Dahl:
Exactly.

Dr. Dave Fabry:
So I think a lot of people don't really think about that combo of the transistor or the integrated circuit with the power supply to make these things portable. And as you mentioned, with zinc-air batteries, by design, there had to be seams that allow air in so that the anode and the cathode of the zinc-air and the air from the outside can power the battery. But now with that lithium ion requirements, becomes the need to make this impervious to moisture. And I think that's where we've really driven the engineers on the quality team to ensure that we're encapsulating that battery fully.

Brian Dahl:
If we want to then focus on the Genesis product, with our Pro8 HydraShield, we've taken a very distinctly different approach to waterproofing this device. And essentially that proof is not relying on one layer or one design feature to keep water out. Having multiple layers, multiple redundant pathways that we know will keep water out in sequence. So saying it differently, it's having multiple insurance policies on a given design. One layer, if that fails, we've got another layer if that fails, and it keeps going because in total, that will keep it dry.

Dr. Dave Fabry:
So talking further about this Genesis, the development of Genesis, as you said, moisture has always been an issue with hearing aids, and we now have IP68 rating. Talk a little bit about what IP68 means to the layperson.

Brian Dahl:
Yeah, so IP68 is an industry standard. So groups of different engineers or different companies, academics get together and they synchronize on different ways of testing classes of products so we can have a common reference. So the IP68 is driven by the IEC committee. So that's a standard methodology that people follow. And when you claim IP68 or whichever different degree there is, you're actually claiming against a very strict, highly defined set of conditions. So the first digit is related to dust or solid objects, and at the lowest level we're talking fingers, so fingers getting into a high voltage electronics box. And then as you go higher, you start to be more resistant to smaller and smaller objects. And the six is dust when pulled under vacuum.
So it's a really good tool to say, "How sealed or how enclosed is this device?" The second is water, and it isn't as sequential as dust in terms of it's harder. There's actually different criteria. So in some of the lower digits, you're talking raindrops, and then in the higher digits, you're talking full submersion. Now the eight is one meter of water for 30 minutes, or technically it's greater than one meter of water and greater than 30 minutes. Now the one issue with the standard though is that when it comes to the IP68, the eight part, the standard actually instructs all users to use fresh water. Now we know that our patients don't sweat fresh drinkable water.

Dr. Dave Fabry:
Correct.

Brian Dahl:
It's salinated, it's salty, it's conductive. So the test, while good, it doesn't quite tell us exactly what our patients are doing and it can be in some ways misleading.

Dr. Dave Fabry:
So let me just ask a couple clarifying questions. So Genesis devices custom and standard are both IP68?

Brian Dahl:
Yes.

Dr. Dave Fabry:
So you mentioned that waterproofing hearing aids has been a goal for a long time. What took Starkey so long to get there?

Brian Dahl:
It's a really good question, and I think we would just first start by saying Starkey didn't want to use that term lightly. And what I mean by that is that waterproof is a very strong word in marketing and in product, but when you start to dig into it, it has a rather loose definition. And so Starkey wanted it to be waterproof for our patient's life. And as a bit of another historical tangent, the idea of proofing something, proofing a product, you could trace that back to the Greek philosophers when they were doing our favorite geometry proofs we did in high school or the idea of bulletproof, which came around in the 15th century where armorers, another technology change from swords to weaponry, they literally shot a bullet at the armor. So there was some objective criteria they were testing against. The same thing with proofing bread.
You're showing that the yeast has in fact activated and you now have what hopefully will be a nice tasting piece of bread. So the general idea of proofing something is having an objective criteria you can measure something against. And when we started to look at it as the engineering and marketing teams, we said, "Well, we wanted to make sure it was appropriate and transparently defined for our customers, and we wanted to make it so that they had a device that was waterproof for what they want." Now, what we mean by that is it isn't meant for scuba diving for multiple reasons. One, you won't have any benefit.

Dr. Dave Fabry:
Correct.

Brian Dahl:
The sound won't go to your ear, but it also isn't designed for that very extreme case, but it's designed for the showers, the dropping in the pools, or anything like that. That's an incidental case that it's waterproof for. Now, you might ask the question, "If we're saying IP68 is just one of many, how do we define waterproof?" And to that, we have really focused on the primary factor which harms hearing aids, which is salinated, salty, vapor or liquid water, because that will corrode metals, cause conductive pathways to have batteries drain out and you might end up with a bad battery life. So we've developed a whole new suite of tests. These tests are focused on cyclical, repetitive wear, not only from the water

or the moisture itself, but also introducing physical stresses. So in some consumer electronic areas, which is a close cousin of hearing aids, a lot of waterproof claims have an asterisk and say, "Only in laboratory conditions." Now we wanted to start to stress it the way our patients do.

Dr. Dave Fabry:
And there's no standard testing available for that.

Brian Dahl:
Correct.

Dr. Dave Fabry:
The IP68 is in a controlled laboratory environment, as you said. The water component, that eight measure is with non-salinated water, fresh water. But we wanted to extend that into the real world.

Brian Dahl:
And in saying it differently, we had to meet our patients where they were.

Dr. Dave Fabry:
Sure.

Brian Dahl:
We can't bring them into a lab and show them this highly standardized test and they'll understand it. So our new suite of tests, we do have a white paper that we've released because we want to show everyone what we really mean by it, but the biggest theme is that we're stressing the device, we're pushing the buttons, we're twisting it, charging it, we're really using it the way a patient would in reality, so that way we can make sure that it's waterproofed for what they expect.

Dr. Dave Fabry:
Outstanding. And as you know, with my custom devices, when we've been on tours, much to your chagrin, I've dropped them into the tube for 20, 30 minutes while streaming, pulled them out, dried them off, run self check, and we're good to go. Maybe the most I have to do is blow a little on the mic port, maybe replace a wax guard but I haven't had a failure on my Genesis devices when I put them to that severe test. And that's even in the controlled environment. I think the other point you raise is a very practical one for patients. Now, throughout my career, 40 years this year as an audiologist, I've never punished a patient when they got into the shower, jumped into the pool, or out in the rain with their devices because, number one, it meant they were in their ears. Number two, in particular, if they hopped in the shower or jumped in the pool, they felt comfortable, natural enough, and sounded natural enough that they forgot to pull them out before they did that.
In the old days, I might have had to send them in for repair or at least find a bag of rice somewhere or a desiccant. But for me now, with the improvements that we've made on the acoustic sides with Genesis in combination with this improvement that is a direct descendant of the transistor and integrated circuits and the improvements in encapsulating that battery means that we can expect, in the manner, that in the manner in which patients are going to use their hearing aids on a day-to-day basis, they're going to be able to be waterproof for their purpose.

Brian Dahl:

Right. And that's a fun thread you pulled on. I mean, ultimately that would be Kilby's dream.

Dr. Dave Fabry:
Sure.

Brian Dahl:
It's now a device that's waterproof and it's invisible to the user, that way they don't notice it every day and they're using it and they happen upon these instances where, back in the fifties and sixties, it would've been disastrous and now it's no longer.

Dr. Dave Fabry:
And then you bring up Kilby, Noyce. I mean, I think we have to throw Gordon Moore in there too. He just died earlier this year. Kilby, a few years back. But the prediction that was made in 1965 about the number of transistors on an integrated circuit doubling every two years held up far longer than Gordon Moore ever thought was going to be the case. But that's really what goes into then the adaptation of these hearing aids to be able to make 80 million adjustments in the background every hour in response to the different acoustic environments that a patient could encounter with the confidence to know that regardless of whether they're in the rain or the snow or the sleet in Minnesota, of which we get plenty, that they're going to keep functioning.

Brian Dahl:
Right. And you brought up another point, drying.

Dr. Dave Fabry:
Yeah.

Brian Dahl:
So we're asked a lot of questions, "Well, if it's waterproof, do I have to dry it?" And I think the quick answer to patients is it's like eating your vegetables. It won't hurt and it's probably good for you. So if you find yourself in a situation where you've had an incident, where you've gone in the shower and you're worried about your device lasting, no harm drying. Just follow what you do, use the desiccants. If you have the dryers, use them because it's just generally good for the device, but we've designed it for those outside cases.

Dr. Dave Fabry:
Got it. So I'm coming back then to IP68. IP68 in itself doesn't mean waterproof.

Brian Dahl:
No.

Dr. Dave Fabry:
But we've developed our own tests in addition to the standardized tests of IP68 that were in excess of IP68. Does IEC need to update its standard to give some measure of a waterproof rating, or are we going to push them to say, "Include more and more of these tests that we know, by comparing to competitive devices, we do really well?"

Brian Dahl:
Yeah, so I think there's a couple things to think about what that is. It's useful under the circumstances which you want to use it. So let's say we're designing a enclosure for a electronics box that's outside, so the boxes that sit on the side of the house, IP68 might be a very useful tool.

Dr. Dave Fabry:
Sure.

Brian Dahl:
Because it's not raining sweaty water, it's raining rainwater. So it might be useful for that application. I think what's important to note though is that as intelligent consumers and intelligent buyers we have to think about why are we buying something. And if we are in a situation that exceeds what something is claiming, we have to find an alternative option. So I would say it's a way of showing waterproof for some instances, but not all. And in the hearing aid industry, we've found that we need to add something that's sweaty and salty and salinated. Now on the question of, "Are we going to petition to IEC?" I haven't thought about it until this point. We do have a bunch of tests that we're proud of and we have finely calibrated to real time use. So maybe at some point you could convince me, but we like to keep them for ours because we want to develop faster than committees.

Dr. Dave Fabry:
And that's one of the beauties, with the quality team, for those of you who are listening and have been to Starkey on the tech center tours, the collaboration between mechanical engineering and quality. If there isn't a test for what we want to subject these devices to, we develop it. And really, like you said, the spray tests where we're spraying water and simulating what it would be regardless of whether you're using fresh water or salinated water to simulate humidity, I guess, can really subject these devices to the corner cases that hearing aid users might encounter in their daily life. And then the water drop test. You mentioned and alluded that the manner in which people are using devices that have user controls on them, we're not just testing them in a static case, but actually talk a little bit about some of the dynamic testing.

Brian Dahl:
So first, I'll say there's a huge engineering team that's behind us. So they're the smart ones doing all the hard work. We just get to talk about it.

Dr. Dave Fabry:
We talk about it.

Brian Dahl:
Yeah. But to your point of when we find a use case that isn't accurately represented either in a standard or in our own test, we quickly iterate and make that test. And the one we thought of the most is that our users are using push buttons where we want them to. That's an indication that they're happy with the device. When push buttons are pressed, that can cause stress on seals or gaskets or other things inside the device or in some designs we've seen across the industry, it literally opens a hole into the device. And if you think of the IP68 test where it's static, underwater, no movement, you can have an artificial seal.

So while it may be sealed in the laboratory, in practice, it may not be. So we're now integrating and combining multiple different stresses or different forces into one test where we're not only combining heat, humidity, salt, force, we're pressing it. And then more importantly, we've zoned in specifically on what is the critical attribute to measure. And in a lot of classic instances, you'll take a device, pass the pretest, and then you subject it to stress and then test it again. And while good and effective, you lose these little subtleties where true innovation can happen. And we're now starting to monitor those in situ. And what it's done is it's really raised the bar for us. So now if we start to see a hint of a deviation, that's now worthy of action. As opposed to it works before, it works after, we're looking for very precise attributes that now classify performance.

Dr. Dave Fabry:
Got it.

Brian Dahl:
But again, it matters, right?

Dr. Dave Fabry:
Yes.

Brian Dahl:
We have to go to that level because things, again, are smaller and smaller. Our patients want more, and those two trends aren't going to stop. They're going to continue as long as they have so far and continue far into the future.

Dr. Dave Fabry:
Love it. So pragmatic tips. Any user tips for professionals or end users related to that Pro8 HydraShield? One of the things I notice is that at least on the RICs, in some cases, getting used to that additional force needed to separate the receiver from the body of the device feels to me, maybe it's just my imagination, but it feels like it takes a little bit more force because we're really looking to ensure that that connection also isn't subjected to corrosive elements.

Brian Dahl:
So if you've ever-

Dr. Dave Fabry:
That's just me?

Brian Dahl:
No, it's intentional. So we have raised the force a little bit, and if you've ever had those pelican boxes that are really hard to close, and you say, "Well, this thing is meant to withstand water. Why is there extra force?" It's because we want it to be not removed. And when you don't remove it, you keep our seals and our sealants intact. So it is a bit of a burden that we've placed onto our professionals, but ultimately the intent is it is best for our patients.

Dr. Dave Fabry:

And it's just until you get used to it. The first time it was like, "Oh, okay, I got to tug a little more." And always my first instinct is, "I'm going to do something wrong," but now that I've been comfortable with it, it becomes commonplace.

Brian Dahl:
And conversely, you have to push a little bit harder to get it in.

Dr. Dave Fabry:
Snap.

Brian Dahl:
And it has to go further in. But that's intentional too. We wanted it to be as recessed as possible because the less surface, you have less risk of getting moisture in and so on and so forth.

Dr. Dave Fabry:
Well, and with the new Snap-Fit Receivers that are intelligent, you'll know instantly whether you've snapped it on all the way or not, because it will identify whether it's a left or right receiver, which power it is, if it's an AP. All of that is smart now, but unless you do that additional little snap, it won't read it.

Brian Dahl:
Right.

Dr. Dave Fabry:
So there's confirmation that shows that you've got everything set up, which is another convenience and efficiency of the new Snap-Fit Receivers.

Brian Dahl:
Right.

Dr. Dave Fabry:
We're talking generally moisture resistance. And one of the other things I know that your team is working on is with regards to the rechargeable battery, we have this phenomenal battery life, 51 hours, 41 or 42 hours for the micro-RIC and the custom devices. We know that we've built in all day use out of the box and for years into the future. But we also know similarly, that battery life... You as an EV owner know that your electric vehicle has a shorter battery life in the winters in Minnesota when it's 20 below zero.

Brian Dahl:
Yeah.

Dr. Dave Fabry:
How about for hearing aids?

Brian Dahl:
Yeah, so it all follows the same basic laws of chemistry. So lithium ions or different batteries are quite simply unintelligent chemical reactions. On one side, you have a potential of lithium atoms, and then

when they kick off an electron, they go to the other side of the battery in the same way that you have... We'll go back to bread and yeast. If it's cold in your house, your yeast won't react, your dough won't rise. Same way with lithium ion. If it's cold or if it gets too cold, you lose that ability for the lithium to move. Now we've taken that all into consideration so that way within the operating temperatures which you find on the box, it will function just fine. But you bring up a good point, over time. And so the biggest question we hear is, "Well, what's my battery life at three, four, or five years?"
And due to the chemical nature and just due to physical breakdown, over time, batteries will reduce their capacity. And there's two primary mechanisms that cause it. The first one, within the materials of the battery, there's separators and different bearers. Things can break down. Think of it like your tire on a car, where you drive a lot, things just start to break. And that breakdown causes resistance to having lithium atoms move. If they don't move, you don't get electrons. Same thing. Sometimes the lithium can get stuck, so chemistry, atoms attracting each other, they can just get stuck and they refuse to go the other side. So over time, you'll see this characteristic degradation of a lithium ion's capacity. Now we work with our vendors, we work with some of the best battery suppliers out there. And what we know with our Genesis products is that at year five, we'll be at 80% capacity. So you do quick math, we put you around 40, 41 hours at year five. Quite a lot of charge still.

Dr. Dave Fabry:
In year five, to compare to our closest competitor today, we're still going to have greater battery life on a single charge than our closest competitor does out of the box.

Brian Dahl:
And it kind of hints at our thesis we've taken with this product. So a lot of people say, "Well, why do I need 51? Why do I need 41?" And there might be corner cases where people want to go multiple days without charging.

Dr. Dave Fabry:
Or a cross by cross, 29 hours.

Brian Dahl:
But the general thesis was just add so much right energy to this device that we're raising that bar. We start at a higher level. So when we take into account the natural physical chemical breakdown, we'll still end up at a very, very high level of charge, even at year five year.

Dr. Dave Fabry:
And coming back around to moisture, I've seen the setup. We're testing in... People don't think that it's humid in Minnesota in the winter, but there's condensation, which is a different type of moisture that can occur if that battery's not encapsulated. I know you're testing at cold temperatures. The body is a pretty good insulator to help the battery life in those cold days, and because of body heat and it's worn in or on the ear. But condensation, again, different type of moisture problem. I know you're testing those.

Brian Dahl:
And this again gets on that theme of miniaturization. So when you start to look at the size of our electronic components, one single raindrop, if the device is unprotected, so there's no seals, there's no top case, there's no anything, nano coating on the circuit board, one raindrop could be enough to cause

problems. And conversely, fog or mist might be enough in some designs to cause problems. So that's why we have to have multiple layers because things are getting smaller, they're getting closer, there's a higher burden for signal integrity on those.

Dr. Dave Fabry:
We've talked about the butterfly effect.

Brian Dahl:
Yes.

Dr. Dave Fabry:
This is the raindrop effect. I like that. And so the Raindrop effect can cascade into bigger quality and reliability and durability issues. And I'm grateful for you and your team working on this. And I feel my, "Okay, Boomer," moment for the day is from Paul Harvey. Now we know the rest of the story. With really a debt of gratitude to Kilby, Noyce, Gordon Moore, and a host of other individuals, acknowledging the team that were really developing transistors, integrated circuits that made hearing aids more dependable, smaller, more reliable, in extreme conditions. I say the ear is a hostile work environment, and I'm grateful for you and your team and the expanded team that has been working on making these devices as bulletproof and waterproof as possible. And I'm also grateful to my high school chemistry and math teachers and my college chemistry and math teachers for helping me understand proofs. And thank you for going through that history. As you know, I, like you, enjoy digging to the root mean cause of some things and seeing where the genesis, pun intended, of an idea or of a concept or of a product was found.

Brian Dahl:
Excellent.

Dr. Dave Fabry:
So I am grateful for you to spend the time with us today unpacking this for, if you will, a deep dive on the waterproofing and moisture resistance and IEC IP ratings. And for our listeners, I'm grateful for you for listening consistently and seeing us, in this case, with Sound Bites for those of you watching on YouTube. If you enjoyed this episode of Sound Bites, please rate and review and even share with your friends, colleagues, networks for those who are interested in really why it is that there's so much technology that goes into developing and designing for the hearing aids, not only at the point of delivery, but for five years down the road. And if you have ideas about other topics or other experts like Brian that we can bring in to talk about the rest of the story, we'd be delighted to do so. Thank you, Brian. If you do want to send an email with your ideas, send it to soundbites@starkey.com. And Brian, I'm grateful for you and your appearance today on Sound Bites.

Brian Dahl:
Thanks for having me, Dave.

Dr. Dave Fabry:
You got it. Look forward to seeing and hearing from you again.