

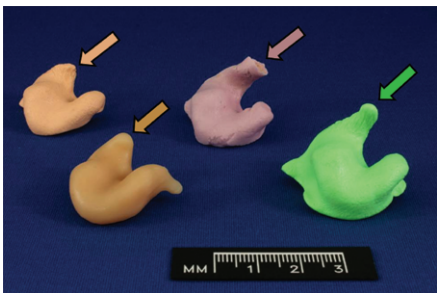
# CUSTOM HEARING PROTECTION HAVE IT YOUR WAY...*MAYBE*

In a culture that insists on “having it your way, “it’s no surprise that we can order virtually anything customized. From shoes to golf clubs, laptops to shower curtains, we’ve gone way beyond the custom-made hamburger. Hearing protection devices are no exception. In addition to a wide array of “off-the-rack” or “one-size-fits-most” hearing protectors is the option to purchase custom earplugs, which are individually molded to each earcanal. The thrust in marketing customized products, whether it’s motorcycles or earplugs, is the notion that a uniquely designed and manufactured product will result in a happier customer. Furthermore, it’s expected that customizing will add expense, but that’s OK because the added benefits of customization outweigh the extra cost. Are these assumptions accurate when applied to custom hearing protection? Or does a custom order meet with an unexpected surprise or two? To make good decisions about using custom products, either for hearing conservation programs or personal use, it’s worth doing some homework first. Let’s evaluate the assumptions about customization, first by looking at what it means to be a “happier customer.”

## **Assumption 1: Custom earplugs provide a better fit and more protection, and thus a “happier customer”.**

All hearing protectors require an air-tight seal in the earcanal to block sound from reaching the inner ear. Like a cork in a bottle, an earplug must fit the earcanal perfectly to keep the sound from leaking around the plug and into the earcanal.

Obtaining an air-tight seal with a custom earplug requires a perfectly made impression of the ear itself; the earplug must exactly match the actual shape of the earcanal. Refer to the separate section on how to make a custom earplug for details, but know that there is a lot of variability in the complete process of manufacturing custom earplugs. For example, the photo below shows four different ear impressions which were made for the same ear. The arrow points to the earcanal part of the earplug. Each impression was



made by an experienced person. Each was made with a different material and technique. Each will block some noise, but the amount of noise reduction is different for each earplug due to the difference in canal length and size. The lesson is that the amount of protection is highly dependent on the quality of the ear impression. Judging the quality of the fit is difficult for the customer, who may not recognize that the degree of protection may not be optimal.

Non-custom earplugs will also give varying amounts of protection if they are not carefully fitted into the ear. Roll-down foam plugs must be properly rolled-down into a tightly compressed cylinder, then, while

the ear is pulled open, the plug will slide into the earcanal. The pressure of the expanded foam against the earcanal creates an acoustic seal along the entire length of the earplug. One significant advantage of a foam earplug over other types is that the foam expands and contracts as the earcanal changes shape. For example, when a person yawns, chews, whistles, etc., the floor of the earcanal moves and can break the seal of the earplug. Flange-style or “pre-molded” earplugs depend on the flexible portion of the flanges to seal the canal. Similar to custom plugs, if the earcanal moves away from the earplug material sound will leak past the earplug.

Some have questioned whether or not a Noise Reduction Rating (NRR) should be applied to custom earplugs since they are individually produced for a specific ear rather than in standard sizes and shapes like non-custom products. However, the NRR measurements for all hearing protection devices, whether custom or non-custom, are conducted according to the Environmental Protection Agency (EPA) hearing protector labeling regulations. Average attenuation with a “best-fit” approach for a group of ten subjects each wearing either a custom plug or a standard earplug with the correct size and shape for her or his ear is used to represent the protective characteristics of the entire population of hearing protection users. An NRR is only a guide for the potential amount of attenuation which can be achieved under ideal conditions. A better method for obtaining specific attenuation information is to conduct an individual “fit test” of each earplug as it is worn by the user.

Field studies have been conducted to discover the amount of noise reduction custom earplugs provide. Findings indicate that custom products, like non-custom products, show a great deal of variability in their “real-world” performance compared to the laboratory measurements (Berger, 2000). The assumption that custom products always provide greater attenuation than non-custom devices isn’t justified. The degree of noise reduction depends on the quality of the fit, which isn’t always accurately reflected by the NRR. In general, the deeper the earplug seals within the earcanal, the higher the attenuation received. Custom earplugs, which reach beyond the second bend of the earcanal, have the greatest potential for maximum noise reduction. Users of deeply inserted earplugs may benefit from applying a lubricant to the earcanal portion of the earplug to insert and remove the earplugs more easily. Individual fit-testing techniques are the best way to measure the noise attenuation of a particular device for a specific person.

## **Assumption 2: A custom earplug is more comfortable.**

The mere idea of a custom fit anything presumes comfort above all else. However, while many custom earplug users do experience a comfortable fit, it can’t be taken for granted. A delicate balance exists between comfort and attenuation. Remember that the purpose of the earplug is to block sound, which requires an air-tight seal in the earcanal. A snugly fitting device that provides good attenuation may cause soreness in the ear because it’s so tight. Also possible is a “comfortable fit” that doesn’t seal the earcanal

well enough to sufficiently reduce the noise.

Uncomfortable earplugs lead to disuse, improper use, and/or encourages altering the earplug (filing or cutting it down) to relieve the discomfort. When custom earplugs are uncomfortable, the user should consult the original dispenser of the product. It may be necessary to remake the impression to get a better fit.

Assumption 2 isn’t true for all users. In general, the tighter the fit, the better the sound-blocking properties, but the higher the chance for discomfort. Evaluation of the noise environment and attenuation requirement is helpful in selecting the appropriate hearing protector. For example, conditions requiring a low degree of attenuation may be perfect for achieving the balance between comfort and attenuation in a custom device.

## **Assumption 3: The benefits of custom earplugs outweigh the added cost.**

Perhaps the biggest benefit to customized products is the positive reaction triggered by the “made-just-for-me” experience of making a custom earplug. For a person who is frustrated, ambivalent, or simply difficult to fit with non-custom devices, having custom hearing protection may provide the special attention needed to convert a non-compliant user into a cooperative one. While the economic advantage of developing more consistent, predictable protection cannot be estimated, caution is needed to guard against the false assumption that custom is always more protective.

Often, special listening conditions can be treated effectively with custom products, such as coupling a custom earplug to a personal listening device, two-way radio, or other communication device. Many features and options are available to adapt hearing protection devices to recreational activities such as a recessed style designed to be worn under a motorcycle helmet, acoustical filtering for listening to or performing music, or minimal attenuation for low-level noise environments. Depending on the manufacturer, customers can often choose from a variety of colors and materials. Some products are designed to work in conjunction with fit validation systems which allows the amount of attenuation received to be measured and documented.

The cost of the products will vary by manufacturer and options selected, however, as expected, the initial outlay will be somewhat offset by the aspect that custom earplugs are longer lasting than less expensive, non-custom devices. There isn’t sufficient scientific data to precisely predict the life-expectancy of a specific custom earplug, however a general rule is to replace earplugs every two to three years. In spite of some claims, custom materials are apt to shrink, crack, and harden over time. Changes in the wearer’s body, such as weight gain or loss of 20 pounds (9 kg) can degrade the fit of the device to the point that a remake is needed (Briskey, 1984). Another consideration is the replacement cost when (not if) devices are lost or damaged. Finally, when using custom hearing protection as part of an employer hearing conservation program, remember to calculate the intangible cost of workers being away from job duties during impression taking, remakes, and fitting appointments.

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## Assumptions reviewed

Custom hearing protection devices have definite advantages for some individuals and for some specific applications. Careful assessment of 1) the purpose of the custom earplug, 2) the attenuation needs, 3) the noise environment, and 4) the individual user characteristics, will help to determine if custom earplugs are the right choice for a specific situation. Review the assumptions about the ability to block sound, comfort, and cost before placing your order, so that “having it your way” doesn’t surprise you. And by the way, don’t forget the fries.

## References

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[www.e-a-r.com/hearingconservation/earlog\\_main.cfm](http://www.e-a-r.com/hearingconservation/earlog_main.cfm)

## Elliott H. Berger

Elliott H. Berger, M.S., is a Division Scientist for 3M Company’s Occupational Health & Environmental Safety Division. For over 30 years he has studied noise and hearing conservation with an emphasis on hearing protection. Elliott chairs the ANSI working group on hearing protectors, has been lead editor for two highly-regarded texts in noise and hearing conservation, served on a National Academy of Science committee evaluating hearing loss in the military, and has presented his research in numerous text book chapters and over 60 published articles.



## How to make a custom earplug

Custom earplugs have been commercially available for over 40 years. What has changed in this time is the number of options, materials, and features offered. There are three main methods for making a custom earplug, outlined below. All methods involve taking an impression of the earcanal with a soft, pliable material that hardens in a short time. See image to the right for a photo of a custom earplug made with the inflatable bladder technique, a laboratory finished earplug, and a mold-in-place custom earplug.

For the mold-in-place version, impression material, usually silicone, is typically either hand-packed or syringed into the earcanal. After hardening, the impression is removed and can be trimmed and coated with a sealant to provide a finished look and to increase the life expectancy of the end product. When syringing, use of an ear dam as described in the next bullet, is required.

With the laboratory-finished product, an ear impression, usually made by a professional, is taken by first inserting a cotton or foam block “ear dam” deeply into the canal, then filling the canal with the silicone material using a large syringe. Once hardened, the impression is removed and sent to a commercial laboratory that makes a cast and then molds the final product with a variety of material options, colors, and features.

A third variety uses a thin expandable bladder that is inflated with a silicone gel and then placed in the earcanal. This impression becomes the final device. It is designed with a channel through the earcanal to allow a small microphone tube to be temporarily inserted through the earplug. The purpose of the tube is to measure the actual attenuation provided by the earplug. An advantage of the bladder design is the ability to incorporate a channel through the earplug that can be used for temporary insertion of a microphone to measure the in-the-ear attenuation using a fit test system, such as the E•A•Rfit™ Validation System.

Regardless of the technique or product used, the performance of the finished product is highly dependent on the quality of the original ear impression. Generally speaking, the highest degree of attenuation will be achieved with a deeply fitted device, one for which the earcanal portion extends at least to, if not slightly past, the second bend of the earcanal. There are risks associated with inserting foreign objects into the earcanal. On occasion, there can be minor discomfort or slight trauma to the earcanal. While rare, there are reported cases of significant damage to the earcanal and middle ear during the impression making process (Wynne et al., 2000). Some states even have laws stipulating which professional groups are allowed to take ear impressions. Even a first good impression can require a remake before an optimal fit is achieved as a small imperfection in the impression can cause an air leak or discomfort to the earcanal.



**A custom earplug made with the inflatable-bladder technique (left), a laboratory-finished earplug (center), and a mold-in-place custom earplug (right).**

Reprinted from the May/June 2011 issue of



safety - iaq - emergency response - instrumentation