

## **THE HEARING PROTECTORS' DESIGN: THE RELATION BETWEEN HEARING PATHOLOGIES AND EARS' IDENTIFICATION**

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### **Abstract**

In this work, the hearing protectors' design was valued. Actually, the hearing protectors' design is focused on the best performance of its material and shape. However, hearing protectors are designed not considering the ear identification (left – right), which means that the worker can use alternatively his hearing protectors. By using the product in this way, bacteria and fungi *Aspergillus niger* may migrate from one ear to another, causing serious pathologies in both ears. This problem was approached in this work, concluding that the hearing protectors' identification is extremely necessary to the worker's health.

### **Keywords**

Hearing Protectors, Hearing Pathologies, Product Design, Occupational Health.

### **1. INTRODUCTION**

Nowadays, the modern industry is known by the high financial investments and complexity of its operations. It means there are vulnerable points, so serious accidents can occur.

An efficient way to avoid accidents at work is by using Individual Protection Equipment (IPE). The body parts with high risks of accidents can be protected with the IPEs, like gloves, boots, goggles, masks and hearing protectors.

However, it must be the last used resource to guarantee the worker safety and health. Some of the providences can be taken to avoid the IPEs use. When it becomes to hearing protectors, the worker can be taken off the noisy room, for example, changing the layout of the industry. Also, it can be changed the localization and working time of the noisy machines.

Another procedure is an adoption of administrative controls that can be used to reduce the noise impacts. Workers can become aware of harmful noise effects and be submitted to trainings to avoid unnecessary expositions. It can be also adopted a system of changing turns between workers, in order to avoid their extended exposition to noise [5].

When the providences described above show themselves inefficient or economic impossible, it must be adopted the use of hearing protectors.

In Brazil, there is a technical standard of disability evaluation (Norma Técnica de Avaliação de Incapacidade para Fins de Benefícios Previdenciários), that follows three circumstances below in which is compulsory the use of hearing protectors:

1. For a strict time interval enforcement of certain tasks during the working day.
2. For a period of time defined as temporary.
3. When indication for IPE must be the only option for reducing the high pressure sound level. [6]

Generally, the IPEs are uncomfortable and interfere at the worker performance. The hearing protector can protect the worker against excessive noises, but at the same time it turns communication tough. Also, there is the worry of transmitting diseases from one ear to another, which is the mainly subject of this article.

## 2. HEARING PROTECTORS' DESCRIPTION

Odysseus, in Greek Mythology, had ordered to their handmaids to plug their ears with bee wax pretending to reduce the mermaids' voices. Since then, a lot of forms of hearing protection have been created. [3]

According to Gerges [3], there are about 2000 types, models and brands of hearing protectors in the international market today.

Williams & Walkins [8] divide the hearing protectors in two main types: earmuffs and earplugs.

Seligman & Nudelmann [6] describe these types as:

### 2.1. Earmuffs

They are formed by two attenuating shells of noise covering the entire ear and are also interconnected through a tensor arc. They have rubber coated with a soft material to enable a good fit in the ear region.

They are subdivided into several types, including the simple, the coupled to the goggles' protectors or helmets, the active, the helmets used for exposure to high levels of sound pressure, and the special ones that act by reducing in a equal form all the frequencies. The last ones are used by musicians to avoid distorting the sound of their music.

### 2.2. Earplugs

The earplugs can be made of special foam, plastic or silicone. They are introduced into the external auditory, being more practical, lighter and cheaper, which makes them more used than the earmuffs.

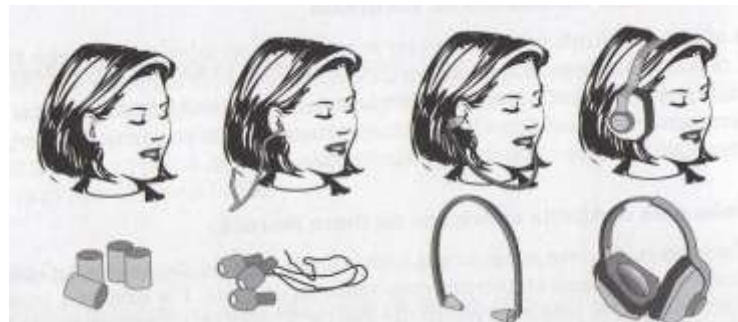


Figure 1: Types of hearing protectors [2]

According to Williams & Walkins [8], there are some advantages and disadvantages for both hearing protectors' types.

### 2.3. Earplugs advantages

1. They are small and easy to have with oneself;
2. They can be properly used;
3. They are more comfortable to use in hot environments;
4. They are more practical to be worn when the head of the user is inside a enclosed and tight space.
5. Their cost is cheaper when compared with earmuffs

### 2.4. Earplugs disadvantages

1. The semi molded ear protectors require more time to effort and to fit;
2. The protection provided by a plug is generally not enough and varies considerably among users;
3. They may become dirty and not hygienic along the time;
4. As they are small, it becomes difficult to see them at a distance and make sure that the employees are using them;
5. They can not be used by people who have infections in external and middle ear.

## **2.5. Earmuffs advantages**

1. They have only one size adjusted the majority of heads;
2. They are normally accepted by the user easier than the earplugs;
3. They are often generally more comfortable than the earplugs;
4. They are not easily misplaced or lost likewise the earplugs

## **2.6. Earmuffs disadvantages**

1. They are more expensive than the earplugs;
2. They depend on the pressure of the bow of the head; by using them, the force can be considerably weakened, and the protection significantly reduced.

For choosing the best hearing protector, some factors must be considered, such as approval certificate, noise attenuation need, comfort for the user, environment and work activity , compatibility with other equipment such as helmets, glasses, etc. and medical disorders.[3]

## **3. THE IDENTIFICATED PROBLEM**

Parameters as mass, materials, shape, the pressure pads, the rod strength, the adjustment, the easy way of hearing protectors' installation and removal are all considered in its design project. In fact, the hearing protectors' project is focused on the best performance of its material and shape. Industry and researchers are concerned about developing the most comfortable and "silent" hearing protector for the user.

Different shapes and identification for different ears are common in the headphones' design, such the earmuffs as the earplugs types. Some kinds of earmuffs protectors are designed considering the ears' shape (left and right), which means that the two sides of this type of hearing protector are different. Moreover, the sides are identified as left and right one. Nevertheless, the earplugs protectors' design does not considerer the ears identification left or right.

The earplugs protectors' design is the mainly point in this article. The lack of ears' identification in the earplugs protectors permits the user to use the plugs alternatively. By using the earplugs in this way transmit some bacteria and fungi from one ear to the other. This problem has never been mentioned by literature as much in Ergonomics, Industrial Design, Audiology and Pathology.

Meanwhile, it is an Industrial Design problem. Therefore, the issue of earplugs protectors' identification can be solved by a project design methodology that considers the safety and healthy of the user. The earplugs protectors' design must regard the hearing diseases transmitted by bacteria and fungi, but also the hearing protectors' problems.

### **3.1. Hearing protectors' problems**

Not only the design projects, but also the instructions about the use of hearing protectors must deal with aspects like safety; discomfort; sirens; effects on verbal communication, directional localization, using time and mainly hygiene.

The hearing protector must be projected in order to reduce possible injuries to the user. Like many objects, they should not have pointed components, so they can not harm the user. When used at the same time, earplugs and earmuffs must be projected in a way that both of them do not interfere in each other and attend their objectives.

As previously mentioned, the earmuffs are more comfortable than the earplugs. However, their fixation strap causes some discomfort. The discomfort caused by the earplugs is due to the way this object is toughly inserted, which makes users take a little time to get used to the object. On the other hand, the earplugs made of expanded foam tend to be less uncomfortable.

One of the greatest difficulties in projecting a hearing protector consists on the shape and the material that must isolate the sound, and at the same time permit that sound frequencies like human voice and sirens could be heard by the user

The effect on directional localization consists on the localization of the sources of the noise, which is better when wearing earmuffs than earplugs. One of the most reasons that make workers not wear the hearing protector is that they eventually can not hear the noise of dangerous machines. When the sense of localization is important to workers safety, it is recommended the use of earplugs.

The effect on using time means that during a long using period of hearing protectors, not only earmuff but also earplugs tend to isolate less the sound frequencies. In general, is recommended to change the earplugs after three months of daily use.

The hygiene is one of the most important questions. When the earmuffs muffle the ears, they tend to increase the transpiration in this region. Such problem could be relieved by using materials like surgical bandage or similar, between pinna and ears. Rarely earmuffs cause ears' pathologies, which turns them an option when the earplugs cause hearing problems.

In order not causing infections and hearing diseases, the earplugs must be handled with clean hands, cleaned after using and kept inside its packaging, which must be cleaned at least once a week.

In Brazil, there is an Internal Committee for the Prevention of Accidents (in Portuguese, Comissão Interna de Prevenção de Acidentes – CIPA), which security technicians are encharged of inspecting the use of the IPEs, as well as to instruct the workers about the right way to wear the hearing protectors.

The hearing protectors and their respective packaging must be washed in boiling water with detergent, as said by CIPA security technicians.

According to technician instructions, one instruction must be pointed out because it is not a printed rule. To avoid migration of bacteria and fungi from one ear to another, the security technicians have been instructing, since about 13 years ago, the workers to knot the extremes of the earplug lace and so, determinate the side with the knot as being the right side of the ear, or vice-versa.

### **3.2. Hearing diseases caused by bacteria**

In the pre-antibiotic era, the secondary bacterial infection of a viral otitis media was common, leading to acute “supurativa” otitis media and risk of spreading bacterial infection to the aerial mastoids cells. From the aerial mastoids cells, the suppuration could reach the brain causing meningitis or brain abscess. This fact today is very rare.

#### **3.2.1 External otitis acute**

The microbial flora is represented, mainly by staphylococci, streptococci, “picocianic” bacillus (*Pseudomonas aeruginosa*), proteus and aspergilos. These bacteria cause external acute and diffuse otitis. This type of otitis is characterized by inflammatory process of the skin of the acoustic meatus. Therefore, it is a “dermite”, where there is scaling of the epithelium, swelling, decreased wax secretion etc. [4].

The treatment consists on wearing dressings, instillating products made of antibiotics and steroids three to four times a day. To soothe the pain, it is recommended local painkillers applications of humid heat.

Among the ways of prevention, it is advisable to avoid cleaning the ear canal with cotton or any other instrument and also dry well the ear. In individuals with a marked predisposition to frequent repetition of external otitis, because of diving practice, this problem can be solved by using specially shaped ear protectors into the ear canal.

#### **3.2.2. Acoustic meatus' furuncle**

The furuncle is a "staphylococcal" infection of the philosebaceous body, due to local infection triggered by one of the etiological factors of acute external otitis, which was already mentioned. In recurrent furuncle, it is possible to identify diabetes mellitus.

#### **3.2.3. Malignant external otitis**

It is a special and serious form of external otitis that is common in very weak patients or diabetic ones. The causative agent is *Pseudomonas aeruginosa*.

### 3.2.4. Pinna pericondrit

Besides the common flora of coccos, the piocianic bacillus plays a leading role in triggering the pericondrit and may even reach the cartilage without prior solution of continuity in teguments skin. Like all other otitis, the pain is intense. The cure is achieved at the expense of scar deformations more or less intense on the pinna.

### 3.2.5. Pinna erysipela

It is generally secondary to a external acute otitis. It is a streptococcal infection. The pinna skin swells up and its surface takes the appearance of a rough rind of orange.

It is common to the process erysipeloides spreading to neighboring regions face. The process is usually followed by temperature raise (39, 40°), chills and rapid pulse.

The chosen treatment is the penicillin injection, procaine or “banzatina” [8].

### 3.3. Hearing diseases caused by fungi

The “otomicose” is an inflammatory process of external acoustic meatus by fungi of the genus *Candida albicans* and *Aspergilo*, the last one in its species *niger* and *fumigatus*. Generally it evolves with intense pain. The “ortoscopic” examination shows the presence of epithelial desquamation and conglomerates of mycelium of variable colors according to the parasite species: white, black or palid yellow. The “otomicose” may involve drilling to the tympanic membrane from outside to inside, opening the way to infection of the tympanum box [4]. The treatment consists on delicate and full removing of mycelium conglomerates, followed by drugs and ointments.

### 3.4. Hearing disease caused by virus

The external hemorrhagic otitis appears to be due to infection by viruses. It is not rare to occur during epidemic outbreaks of influenza. Treatment consists on painkillers prescription and warming the place. Antibiotics do not have any beneficial effect [4].

## 4. THE DESIGN PROJECT

Although it harms a low number of workers, the hearing pathologies caused by bacteria and fungi can be avoided at least in one of the ears by using a well designed earplug.

The briefing for this new hearing protector must cover many aspects. First, it must have some kind of right-left indication in the plugs. Second, must be easy to clean. Then, it is necessary to determinate the parameters already mentioned, such as mass, materials, shape, the pressure pads, the rod strength, the production process, the product cost, its useful life and the least, but not the less important, the capacity to isolate sound properly.

One of the competencies of the designer is to develop suitable and adapted products to humans. Among the many relevant aspects of the relation product-user, it is essential to cover the function of the product, safety, ergonomics, hygiene, the adaptability to the user, as well as subjective qualities such as color.

## 5. CONCLUSION

The designer has his profile consisted of many aspects and various characteristics that always add new information during his practical activity. The steady performance of the professional with the market, the permanent contact with various projects and the cultural and productive world is the most solid way to acquire the knowledge necessary to practice Design [3].

Design is an interdisciplinary projetual activity. So there are interfaces to other areas of knowledge such as Medicine, Engineering, Physics, Chemistry, Philosophy, Arts, Biology, Sociology, etc.

Medicine, especially Pathology and Audiology, has greatly contributed in drawing up this work. However, the design project proposed to this product, which is the new earplug, contributes to Medicine in the prevention of hearing pathologies. The feedback provided by the Industrial Design is one of the most intelligent and promising way to deal with knowledge.

Besides interdisciplinary contribution, the largest contribution of this work is for occupational safety and health of the worker.

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