

# COMFORT FROM HEARING PROTECTORS

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## 1 Introduction

The two properties of utmost importance when dealing with hearing protectors are sound attenuation and comfort. Sound attenuation, defined as the difference between the sound levels of the open and the protected ear is properly defined and there are standardized methods for its measurement.

There is no clear definition, however, on hearing protector comfort, nor are there standards for its measurement. Also, research done regarding comfort appears to be limited. A search conducted on the popular Web of Science database, shows that between the years 1970 and 2014, 208 papers were published dealing with attenuation, while there were only 22 papers related to comfort.

This paper critically reviews studies pertinent to comfort from different types of hearing protectors (earplugs, earmuffs, and semi-inserts).

Comfort is an evaluation that may be defined quite simply as “all is well.” It is inherently subjective in nature and is quite complex in nature. It is also dependent on issues other than the protector itself, but related to the environment, such as temperature and humidity at the workplace. Other factors involved are the need for speech intelligibility and the anatomical differences among wearers.

In contrast, discomfort may be defined (and measured) along many dimensions. Some examples of those dimensions are shown in Table 1.:

Pressure on the eardrum
Irritation of the canal lining
Feeling of fullness
Occlusion effect
Heaviness
Heat and humidity
Pressure against the head
Interference with headgear, eyeglasses and long hair

**Table 1:** Some factors for discomfort

Over the years researchers have taken different approaches to study comfort. Some did literature searches; other did lab and/or field studies. In general, the lab studies involved short exposure times. Nonetheless, some

researchers claim that short exposures lead to similar outcomes than would be expected from longer exposures typical of the work environment.

When studying comfort of earmuffs, some focused on the force exerted against the head, while others were interested in pressure measurement. Also there are studies regarding the influence of heat and humidity on comfort. Finally, some had tried to put together sound attenuation and comfort. Almost all of them made use of some sort of questionnaire to quantify the weight of the different factors of discomfort. Table 2 shows an example of a questionnaire.

### How does the protector feel?

Painless						Painful
Tight						Loose
Heavy						Light

**Table 2:** Example of Bipolar Scales

This presentation will critically review studies on comfort in hearing protectors completed over the past 25 years, with the intention of developing a linear regression procedure for ranking hearing protectors on the basis of comfort under specified conditions. This approach will allow us to systematically evaluate the relative contribution of different factors on comfort.

## 2 Discomfort factors

As defined in Wikipedia, “*comfort (or comfortability, or being comfortable) is a sense of physical or psychological ease, often characterized as a lack of hardship*”. Further, “*because of the personal nature of positive associations, psychological comfort is highly subjective*”.

For the purpose of this paper, it may be simpler to deal with the antonym of comfort that is, discomfort. The definition of comfort involves several contributing factors that are not simple to define. For example, if we qualify a pair of shoes as “comfortable”, there is no need to explain why: it is implicit that those shoes fulfill every requirement for feeling comfortable. However, if the shoes are not comfortable, then one must define the quality or the qualities that make them feel as such and those can be numerous. The same concept can be applied to hearing protectors. As shown further below, there are many factors that can make them uncomfortable, and therefore create discomfort.

As a start, we shall propose that no Personal Protective Equipment (PPE) is comfortable. All PPEs imply a certain degree of discomfort, probably related to the fact that they

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are “extra garments”, not needed for performing the task at hand.

There are several qualities that can cause discomfort. For instance, safety shoes are heavy and cumbersome. Hard hats are also heavy and particularly cumbersome to wear in a hot and humid work environment, where users tend to sweat. Gloves can be uncomfortable in a similar environment. On top of perspiration, they may cause skin reactions such as eczema. Safety glasses can be considered the best accepted PPE. They are typically light and, because most people are used to wearing glasses, there is a little perceived discomfort or rejection

It is a common perception that, with respect to comfort, respirators and hearing protectors are the worst offenders of all. Depending on the type, respirators tend to restrict breathing. Also they are often heavy and hot. Use of HPDs, in addition to comfort factors, interfere with hearing (and understanding) of speech, warning sounds and alarms. There is however, a fundamental difference on how each of those two devices is accepted. Respirators are perceived as (and they are) life-savers. Very little effort is needed to convince workers that they must wear them for their own good.

The situation is different with hearing protectors: in general, as mentioned above, there is much resistance to their wear. A greater amount of effort and time is also required to build awareness regarding noise as a hazard. (« Ears don't bleed »).

It should be noted that some comfort factors are a function of the length of time HPDs are worn. There are instances when devices appear comfortable when they are first donned. After a while, however, the user may start feeling the weight/pressure and finds them burdensome. This is often the case with muffs, particularly when cap-mounted. Other types of hearing protectors, on the contrary, feel uncomfortable when they are first donned, but after a while, the wearer forgets that he has them on. This is often the case with earplugs.

Based on the above considerations, one would expect that comfort studies should be performed over extended periods of time. Surprisingly, one study came to the conclusion that properly designed, short-duration tests can provide comfort and user acceptance data equivalent to long-duration work experiences.

### 3 Conclusions

The analysis in this paper shows that the issue of comfort (or discomfort) is a very difficult subject to deal with. Some of the reasons were quoted at the beginning of the present paper. They all derive from its complexity and the several factors subjective and objective involved are:

a) Subjective.

Different subjects perceive and react differently to the same protector. Shape and color tend to be important.

b) Objective.

- a. Anatomical differences cause different effects.
- b. Duration of the wear
- c. Environmental factors (mainly heat and humidity)
- d. Types of protectors (plugs, muffs and semi-inserts) and different design of the same.

Regarding the studies proper, they have been different approaches, such as:

- Short and long duration,
- Laboratory, field and mixed.
- Questionnaires
- Comparison between HPDs of the same type

As per recommendations for future works, it appears that the best approach is to conduct separate study for different types of HPDs.