

a. *Cotton*. The upper dashed curve in Figure 32 shows the noise reduction typical of ordinary, dry cotton wads placed in the ears. The protection is poor throughout the low frequency range, but improves slightly at high frequencies. This possibly accounts for the misleading claims of some enthusiastic users of ordinary cotton. The reduction in high frequency noise decreases the annoyance of the noise, and the user believes that his increased comfort means satisfactory protection.

b. *Impregnated Cotton*. The solid curve in Figure 32 shows the typical noise reduction for properly fitted wax-impregnated cotton plugs. These plugs are cylinders $\frac{1}{2}$ inch in diameter and about $\frac{3}{4}$ inch long. Their average weight

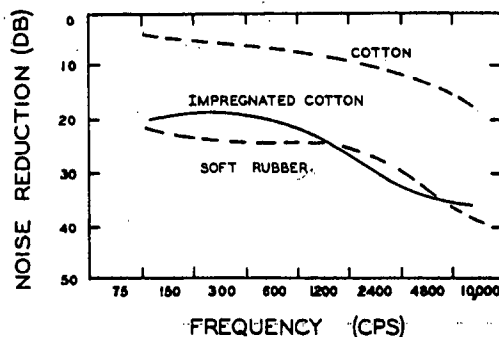


Figure 32. Maximum noise reduction to be expected from ear plugs. For average noise reduction subtract 5 to 10 db. Data were averaged from several sources.^{25,26}

is a little over 2 grams. They must be warmed and rolled in the hand before insertion; when the material has the consistency of putty, the plug may be pressed into the ear. Care must be taken to insure that the plug conforms to the ear canal. At tropical temperatures, the wax softens and becomes sticky and the plugs are, therefore, unsatisfactory. Under all conditions of use, they collect and retain any dirt to which they are exposed. These plugs are relatively expendable; however, since a new pair each day for each worker would not be unreasonably expensive. If the plugs must be removed many times each day, it may not be economical to use new plugs each time. Also, it is inconvenient to remold the plugs each time.

c. *Soft Rubber*. The lower dashed curve in Figure 32 shows the typical noise reduction for properly fitted soft rubber plugs. These plugs are capsules of a soft rubberlike material weighing about $\frac{1}{2}$ gram, shaped to facilitate insertion and retention in the ear canal. Most manufacturers make the plugs in three sizes for comfortable fit in small, medium, and large ears. They should be made of a special nontoxic elastomeric material that is resistant to the action of ear

wax. The plugs must be carefully inserted to provide adequate protection. They have small tabs on the outside end of the plug to facilitate removal. Unless these plugs are cleaned regularly with soap and water, they will collect wax and dirt. Their average cost is slightly less than a dollar a pair. Therefore, they are not as expendable as the impregnated-cotton plugs.

Attempts have been made to design a plug that excludes noise, but not speech. One such attempt is a "filter" plug, which has a small perforation that allows low frequency and mid-frequency sounds to be transmitted. The noise reduction characteristic is no better than that for cotton up to the 600 to 1200 c.p.s. band. Above this band the characteristic is about the same as the average for soft rubber plugs. Another attempt at an ear plug that will pass speech utilizes a tiny valve that closes during an intense pressure pulse of long duration. At all other times the valve is open and the plug has a noise reduction similar to the "filter" type.

d. *Muffs and Helmets*. Muffs that cover the outer ear and are held in place by means of a headband have a noise reduction characteristic slightly better than that of the filter type of ear plug, but usually not as good as the solid plug. It is difficult to obtain a good seal between the muff and the ear, and for this reason, the low frequency noise reduction may be poor. Muffs that have a very firm headband will provide protection equivalent to that of a solid plug, but they may be uncomfortable if worn for long periods. A new muff with a fluid-filled seal apparently overcomes this difficulty. Helmets are, in general, inferior to muffs.

This type of protector can be put on and removed quickly since nothing need be inserted in the ear canal. Therefore, the muffs and helmets are useful in situations that require frequent removal of ear protection or for personnel who cannot wear regular protection. They may be worn in addition to plugs if extra protection is needed. This combination approaches the theoretical limit of ear protection.²⁷

3. Medical Considerations

A few employees will require treatment before they can wear ear plugs safely. Current medical opinion indicates that eczema and draining of the ears are the major reasons for not wearing ear plugs. Usually these difficulties can be corrected by treatment in the plant or by the employee's physician. The employee can then participate in the ear-plug program within a short time. During treatment, the employee may wear ear muffs.

A few who should be treated may not be aware of their condition. Complete screening of all exposed employees may be accomplished by means of an otoscopic examination performed by the plant physician. If an audiometer program is to be conducted, this examination will probably be planned for the time of the first audiogram.

²⁷H. E. von Gierke, Personal protection, *Am. Ind. Hyg. Assoc. Quart.*, 15, 44 (1954).