

Real world attenuation of full-block generic ear plugs: Do numbers converge?

A comparison of subject-fit measurements and two field studies

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EXECUTIVE SUMMARY. This paper investigates the real-world attenuation of generic full-block ear plugs, both foam and premoulded (reusable). The plugs have official M values in the range 22-35 dB.

It is found that the attenuation for the different data sets converge to a surprising degree. Typical standard deviations are 7-12 dB. One may expect that, in the real world, 80-90% of trained and motivated users should be able to achieve an attenuation of about 15 dB for broad band noise and about 20 dB for high-frequency noise. These are thus realistic values to base a hearing conservation program on. To achieve this level of performance, it is necessary that individual training is performed and a good selection of products is available. Even then, one must be prepared that perhaps 10-15% of users will need a different protector (such as an ear muff or a custom moulded plug).

The data for the poorer performing users do not correlate well with label data. Rather, for 75 percentile and higher, the attenuation of various plugs are practically the same. In other words, for the low-performing users, a plug with a labelled attenuation value of 22 dB are not likely to perform any worse than one at 35 dB. Obtaining a shallow fit is what counts.

At the other end, official label data from type testing (ISO 4869-1) correlate well with the better performing users. The higher the label value, the less users are likely to achieve them. In general, the label mean attenuation may be achieved by some 20-30% of users.

Due to the large user variation, such ear plugs are not very suitable for schemes trying to balance overprotection and underprotection. For choosing products likely to be suitable for a group of users (based on exposure level), a moderate 20-30% derating could be recommended to reflect the "shift of the mean" likely to occur in the real world. Such a derating really should be frequency dependent, with a higher derating for the low frequencies than the high.

1. Introduction

It is well known that the typical attenuation of hearing protectors in the real world (RW) differ from those of the label data that come with the products. The difference may be particularly large for ear plugs, which require considerable skill to fit properly.

European label data, like SNR and HML, are usually derived from the mean minus one standard deviation and presented as "Assumed Protection Values". This means that, if a hearing protector is worn in the same way (and is in the same good condition) as during the testing made for the type approval, the labeled attenuation (or more) should be achieved by 84% of the users.

Field studies consistently show that this is not the case. This should come as no surprise. Indeed, the test standard ISO 4869-1 (1990) used for labelling purposes in Europe, cautions that the test procedure has been set up to achieve consistency between products rather than a realistic field performance:

The method and procedures are designed to yield values close to the maximum attenuation which are not normally attained under field conditions. This approach has been adopted because the attenuation values can then be consistently reproduced.

For the HSE supervisor or end user this raises the crucial question: what attenuation can most users expect to achieve or exceed?

The simple answer is that "it depends". The challenge is the huge *individual variation* of ear plug attenuation due to different fitting. However, as we shall see, the *statistical variation* for a population of *trained* users seems to be a lot more predictable.

2. The data sets (studies)

Through the years, many field surveys have been made to investigate the real-world attenuation of ear plugs. Often, these studies have shown very discouraging results for the low-performing users. For the 80-90 percentiles it is common to find values well below 10 dB for many products. So, while ear plugs provide reasonable to good protection for most people, some are really struggling to obtain a good fit.

The data sets considered in this paper are believed to reflect the higher end of field data. They are:

- a) Subject fit tests according to ANSI S12.6-1997, method B, official data for Brazil.
- b) BGIA field study, Germany (2005-2007).
- c) Flint Metal Center longitudinal field study, USA (2004-2005).
- d) Example of individual fit testing, before and after results (Honeywell).

3. The critical issue: fitting

The attenuation that an ear plug provides depends on how the user inserts it. The plug must make a proper *seal* so that no serious leakage occurs.

The attenuation further depends on the insertion *depth*. Figure 1 shows this for a foam plug. In this test, experimenters carefully inserted the plug in three different ways on the test subjects [1]:

- a) Partial insertion - 15-20% of the plug in the ear canal
- b) Standard insertion - typical laboratory fit with 50-60% in the canal.
- c) Deep insertion, i.e. the maximum depth of insertion that could be practically achieved (80-100% in the canal).

The resulting mean attenuation for each fit is shown in figure 3-1.

Clearly, the insertion depth makes the biggest difference at low frequencies. At the high frequencies, from 2000 Hz, the insertion depth has only a small effect. Here, obtaining a seal, even if shallow, is sufficient to obtain a high attenuation.

In one way this is assuring. Even the partial insertion ensures good protection at high frequencies (2-8 kHz), where the risk of hearing damage is largest. However, the potentially strong dependence of attenuation with frequency presents a challenge for those trying to estimate noise exposure to the ear.

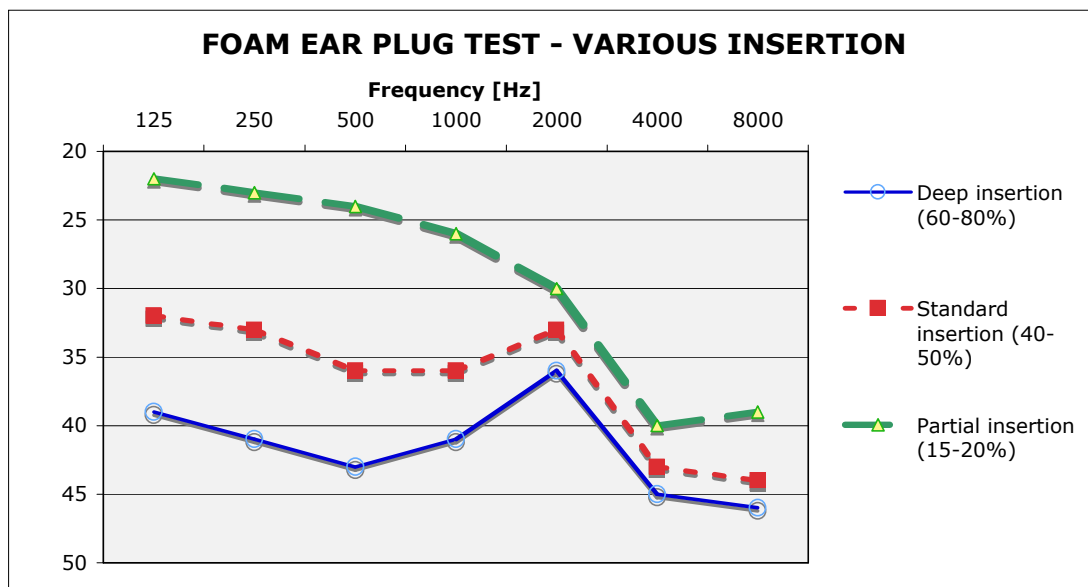


Figure 3-1. Mean attenuation from a group of subjects with different depth of insertion of the same foam ear plug (courtesy EAR).

The relation between the different fits in this study (Berger et al) is further explored in Figure 3-2. The curves show the *relative* performance of the partial fit to the standard and deep fit. At 125-500 Hz, the partial fit attenuation is 60-70% of the better fits, rising to 80-90% at 2000-8000 Hz.

As an average for the five frequencies 250-4000 Hz, the *shift of the mean* is as follows:

- Partial vs deep: 30% (13 dB)
- Partial vs normal: 21% (8 dB)

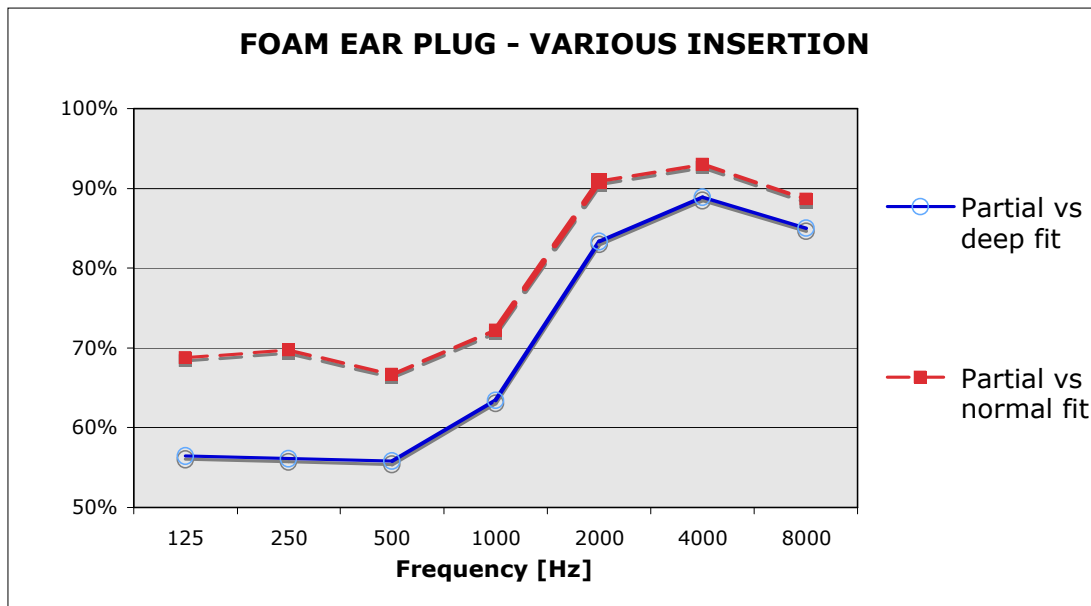


Figure 3-2. Relative attenuation of partial fit to normal fit (dashed line) and deep fit (solid line).

4. Subject fit tests

4.1. Introduction

Type tests on hearing protectors are carried out on persons that have been trained and assisted by a test supervisor. This results in very good fitting for most users and overall attenuation values which are indeed likely to be "close to the maximum attenuation".

Subject fit testing are also made in the laboratory, using audiometry in a well controlled testing environment. However, these tests are carried out on persons who are unfamiliar with hearing protectors. They are given minimal experimenter assistance and no explicit training beyond written instructions. They are then asked to fit the plug the best way they can.

4.2. Method

The results? As one may expect, subject fit tests produce lower attenuation than the experimenter-assisted ones. Still, the overall attenuation achieved by these inexperienced, but motivated, users turn out to be equal to or better than what is achieved in field tests made on trained industrial and military users! [2]. Subject fit tests also seem to rank order the attenuation of ear plugs for the low performance users much better than experimenter-supervised methods do [2].

So far, subject fit data have found limited use. A major exception is Brazil, where subject fit testing according to ANSI S12-6-1997 (method B) are mandatory for labelling purposes. NIOSH (National Institute of Safety and Health) in the US also acknowledges subject fit data to be used as "field attenuation" without further correction or derating.

The subject fit tests presented here have been made according to ANSI S12.6-1997, method B. Each plug has been tested on 20 persons.

4.3. Description of plugs

Data for seven foam plugs and six premoulded plugs are presented here. All are full-block types with label "M" values (according to EN 352-2) in the range M=22-35 dB.

An overview of all ear plugs covered in this paper is given in Enclosure 1.

4.4. Mean attenuation and shift of the mean (field vs lab)

The mean attenuation for each of the seven foam plugs is presented in figure 4-1. For comparison the "partial insertion" curve from figure 3-1 is included.

The first observation is that the variation between the various plugs is fairly small. The attenuation curves mostly fall within a fairly narrow 5-8 dB band.

The curve shape (variation with frequency) are essentially the same as the "partial insertion mean". The attenuation is about 20 dB up to 1000 Hz, then rising to 30-40 dB at 4-8 kHz.

The SF attenuation curves for the premoulded (reusable) plugs are similar, but somewhat flatter, i.e. with less attenuation at the high frequencies 2000-8000 Hz.

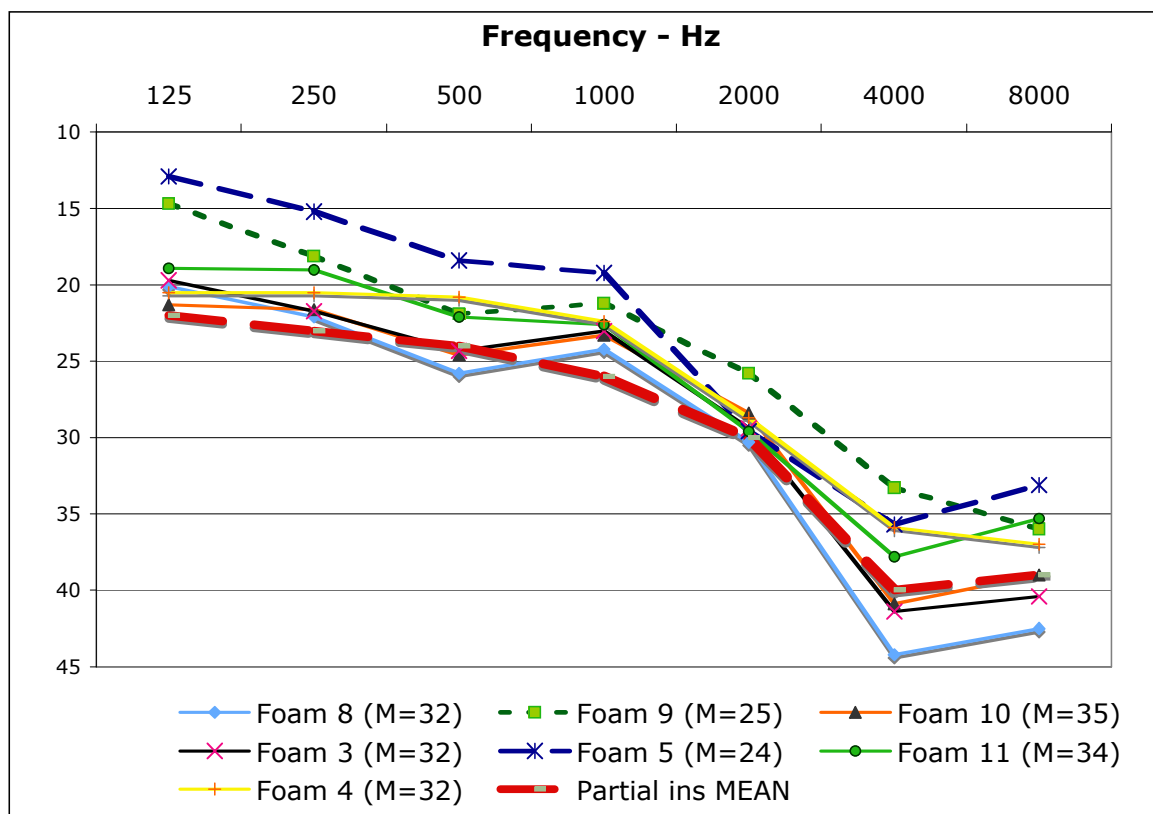


Figure 4-1. Subject fit mean attenuation for seven foam ear plugs. The partial insertion mean from figure 3-1 is included for comparison.

4.3. User variation

As expected, the variation in these subject fit data is larger than for ISO 4869-1 tests. Average standard deviations (250-4000 Hz arithmetic average) are 7-9 dB both for the foam and premoulded plugs.

5. ONE SIZE FITS ALL? PROBABLY NOT!

In type testing an attempt is made to fit a single type/size of hearing protector to a group of random persons. For ear plugs, it is to be expected that this "one product fits all" approach will fail for some persons. This may be due to wrong size or "difficult" ear canals producing shallow or leaky insertions.

In the field, users are hopefully offered a choice of various products. This provides a different background to performance than tests made of only one product at a time. If people are tested with their preferred choice of ear plug (or possibly ear muffs) among a reasonable selection, chances may be that the fit will improve.

6. GERMAN FIELD STUDY, BGIA (2005-2007)

6.1. Introduction

An extensive field study of hearing protectors was carried out in the German metal work industry in 2005-2007 [3]. About 800 individual measurements were made in several locations. The field audiometry measurements were made in an audiometry room in a mobile unit.

Field users are generally inexperienced with audiometry and thus are likely to report lower attenuation numbers than an experienced person would do. Also, the higher background noise in the mobile unit at low frequencies will lead to lower reported attenuation than in a better sound insulated laboratory. The data were statistically corrected for these effects, i.e. to represent what a typical experienced user would report in a laboratory but *with the fit of the workers tested*.

Sample sizes were considered sufficient to include five foam plugs and two premoulded. The smallest sample size was 25 persons. Five frequencies were tested (250, 500, 1000, 2000 and 4000 Hz).

6.2 Mean attenuation and shift of the mean (field vs lab)

The overall mean attenuation for each of the seven plugs in this study is presented in Figure 6-1. Again, the *partial insertion* curve of figure 3-1 is included.

The shape of the curves should now be familiar to the reader. The attenuation for all plugs fall within a narrow 5 dB band starting at 20 dB at 250 Hz gradually increasing to 35 dB at 4000 Hz. The attenuation values are very similar to the subject fit data, but a little bit higher.

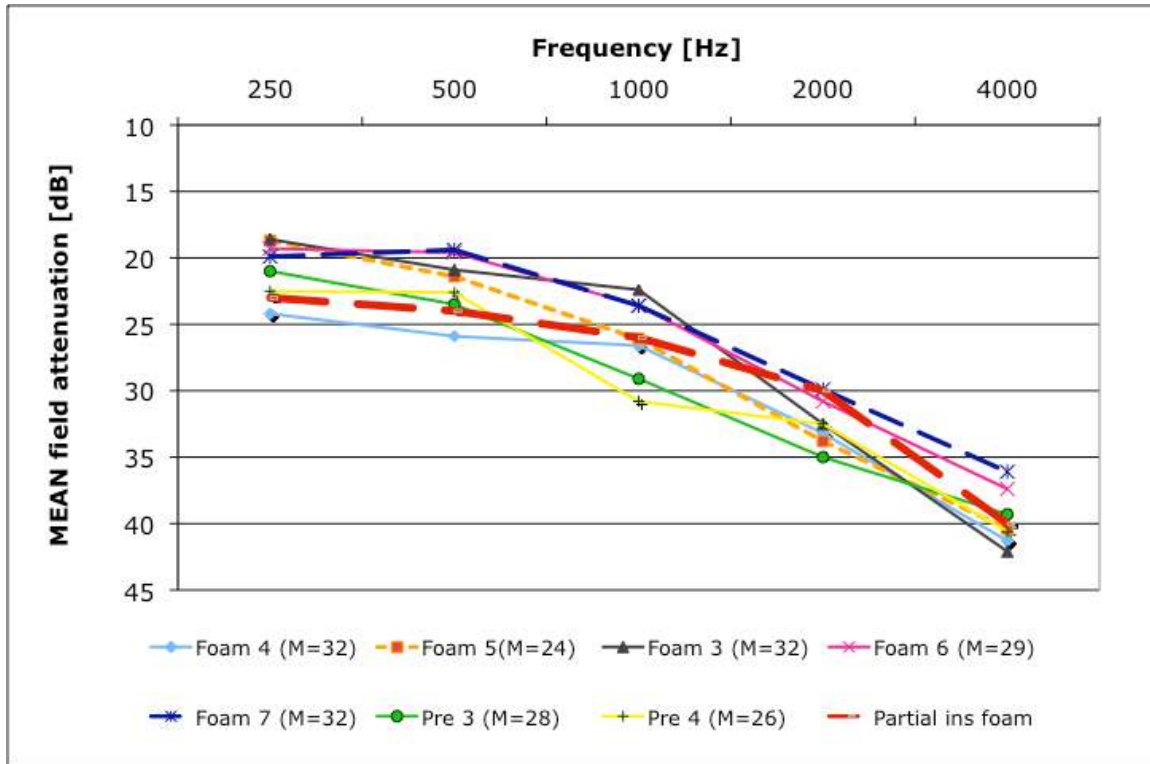


Figure 6-1. Mean attenuation for seven generic ear plugs (five foam and two premoulded), BGIA study (2005-2007). The partial insertion mean from figure 3-1 is included for comparison.

Figure 6-2 shows the relative attenuation of the field mean to the label mean (ISO 4869-1). The relative attenuation of the field mean is 50-75% at the low frequencies, rising to 85-100% at the highest frequencies.

The soft foam plugs (with $M > 30$ dB) have the lowest relative field values. The difference is particularly large at the two lowest frequencies, 250 and 500 Hz. The two premoulded plugs and the more moderate foam plug no 5 ($M=24-28$) are closer to the official ISO 4869-1 data.

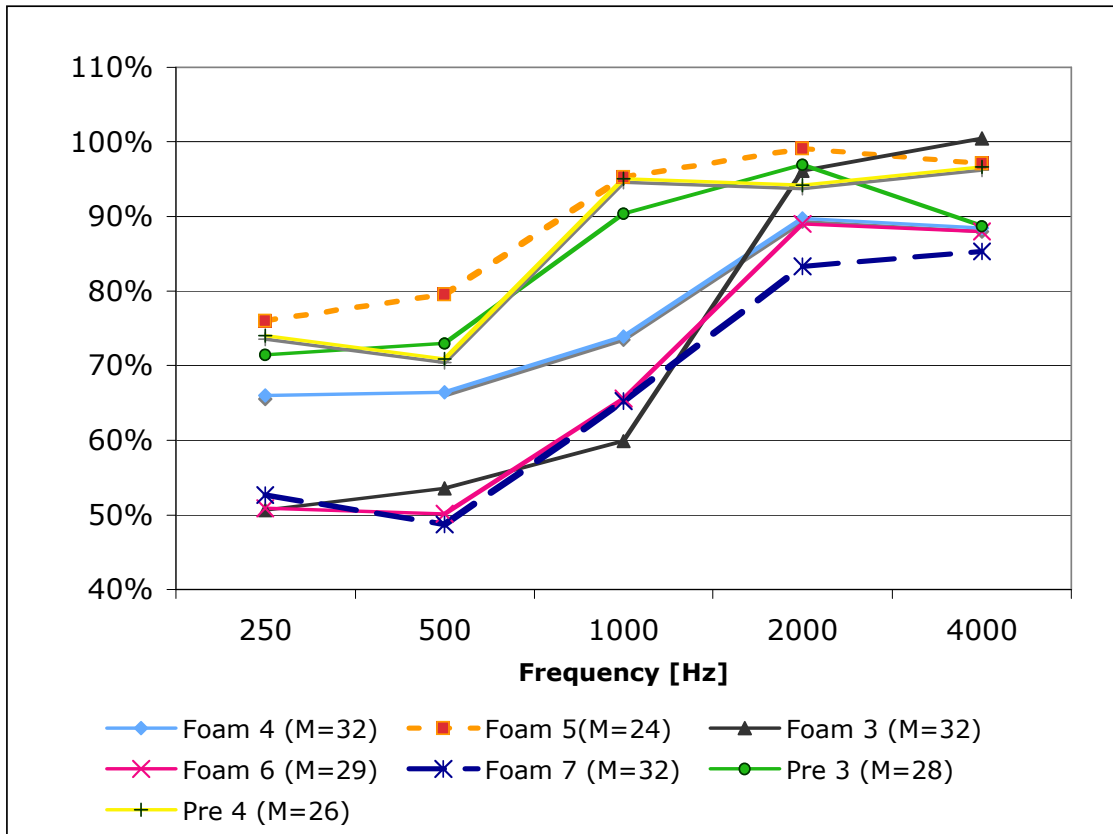


Figure 6-2. Relative attenuation of the field mean as percentage of the ISO 4869-1 mean.

Table 6-1 summarizes the average *shift of the mean* for foam (5 plugs) and premoulded (2 plugs). In general, the relative performance of the foam plugs is poorer than the premoulded, except for foam 5.

Table 6-1. Shift of the mean, relative and absolute

	Low 250-500 Hz	All (medium) 250-4000 Hz	High 2000-4000
Relative field attenuation in %			
- Foam (5 plugs)	60%	75%	92%
- Foam 5 only	78%	89%	98%
- Premoulded (2 plugs)	72%	85%	94%
Absolute shift of mean in dB			
- Foam (5 plugs)	15 dB	9 dB	3 dB
- Foam 5 only	6 dB	3 dB	1 dB
- Premoulded (2 plugs)	9 dB	5 dB	2 dB

6.3. Variation

Standard deviations (250-4000 Hz arithmetic average) for each plug is 8-12 dB with an average of 10 dB both for the foam and premoulded plugs.

7. FIELD STUDY AT FLINT METAL CENTER, USA (2004-2005)

7.1. Introduction

An extensive field study of ear plugs was carried out at the Flint Metal Center in Michigan, USA, in 2004-2005 [4]. The plant was chosen for several reasons, including strong management interest and a good reputation for use of hearing protection.

The noise environment in the plant is impulsive (stamping machines) with typical reported noise exposures of 95-100 dB for an 8 hour shift.

The plant routinely provided workers with five standard plugs to choose from (see Enclosure 1). Most users preferred foam plugs no 1 or 2.

The Flint study provides interesting as a well documented example of what can be expected in a workplace with high attention to hearing protection in a fairly noisy environment.

7.2. Field attenuation

Measurements of attenuation were carried out up to four times for the same workers during the 13 month duration of the study.

The report [1] provides attenuation data as PARs (Personal Attenuation Ratings). The PAR is a single value parameter based on a weighted spectrum with a difference between C-weighted and A-weighted Leq levels (C-A) of 2 dB. In terms of frequency the data should thus be reasonably comparable with the "M" value used in the HML method (ISO 4869-2) which similarly has a C-A difference of 2 dB. Such a parameter is applicable to a noise spectrum which is "medium" and broad-band.

The data from the Flint survey is presented as five percentiles 10 – 25 – 50 – 75 – 90. The PAR attenuation for each plug is shown in Figure 7-1.

Most notable, the attenuation for the 75 and 90 percentiles is practically the same for all plugs. This is in spite of label "M" values differing by up to 7 dB. For the 75 percentile the average attenuation is 19 dB and for the 90 percentile 14 dB.

However, the better performing users of the two plugs with the highest label values (soft foam) do show a significantly higher attenuation than the rest. For the 25 percentile the difference is 7-10 dB.

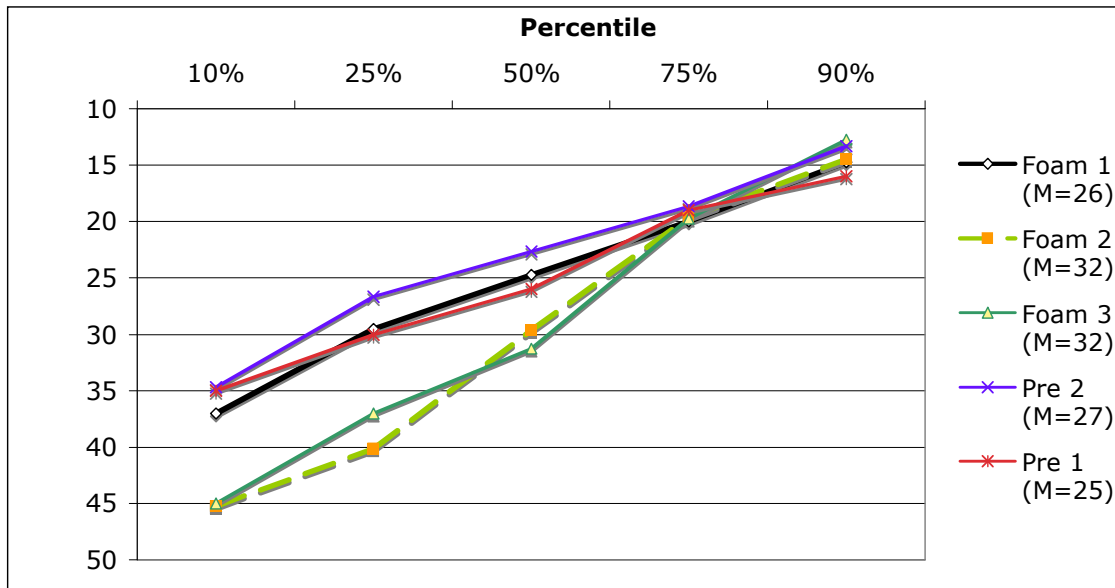


Figure 7-1. Attenuation of five standard ear plugs by percentile, Flint Metal Center, USA.

8. COMPARING THE DATA SETS

8.1. Absolute attenuation by percentiles

Table 8-1 and 8-2 summarizes the broad-band attenuation (M-type spectrum) by percentiles, sometimes called the *protection rate*. Table 8-1 shows foam plugs averaged, table 8-2 premoulded.

As one can see, the data very much converge. They all point to an attenuation of *about 18-19 dB for the 75 percentile and 14-15 dB for the 90 percentile*.

(For the SF and German data, the percentiles are calculated from the mean and SD, assuming a normal distribution, only the Flint data are real percentiles).

Table 8-1. Foam plug average attenuation by percentiles, M-spectrum

	No of plugs	10	25	50	75	90
Subject fit	7	34	29	24	18	14
German BGIA	5	38	32	25	18	14
Flint	3	42	36	29	19	14
Average		38	32	26	18	14

Table 8-2. Premoulded plug average attenuation by percentiles, M-spectrum.

	No of plugs	10	25	50	75	90
Subject fit	6	31	26	24	16	12
German BGIA	2	40	34	26	21	15
Flint	2	35	28	24	19	15
Average		35	29	25	19	14

8.2. Attenuation by frequency

Figure 8-1 shows the mean attenuation of the subject fit (SF) and the german field study. Data are averaged for all foam plugs and premoulded plugs in each study.

Comparing the two data sets, two major observations are:

1. The foam plug data are very similar
2. The premoulded SF attenuation is lower than the field data, particularly at 2000-4000 Hz.

The SF data thus seem to be a very good indication of field performance for foam plugs, but they slightly underestimate the attenuation of premoulded plugs.

A reason for this may be that the users with the more "difficult" ear canals are likely to use foam plugs. In the Flint study, premoulded plugs were worn by only about 10% of the workers, suggesting that these were people who obtained a good fit with these devices.

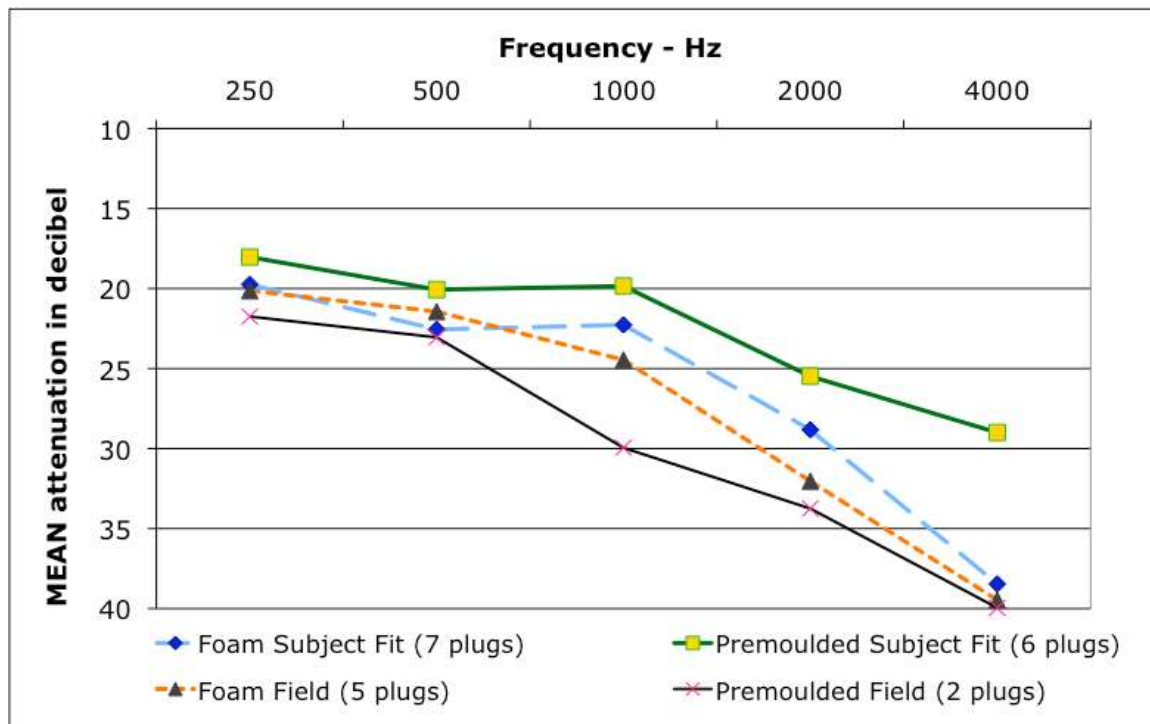


Figure 8-1. Mean attenuation – average for foam and premoulded plugs, subject fit and field data.

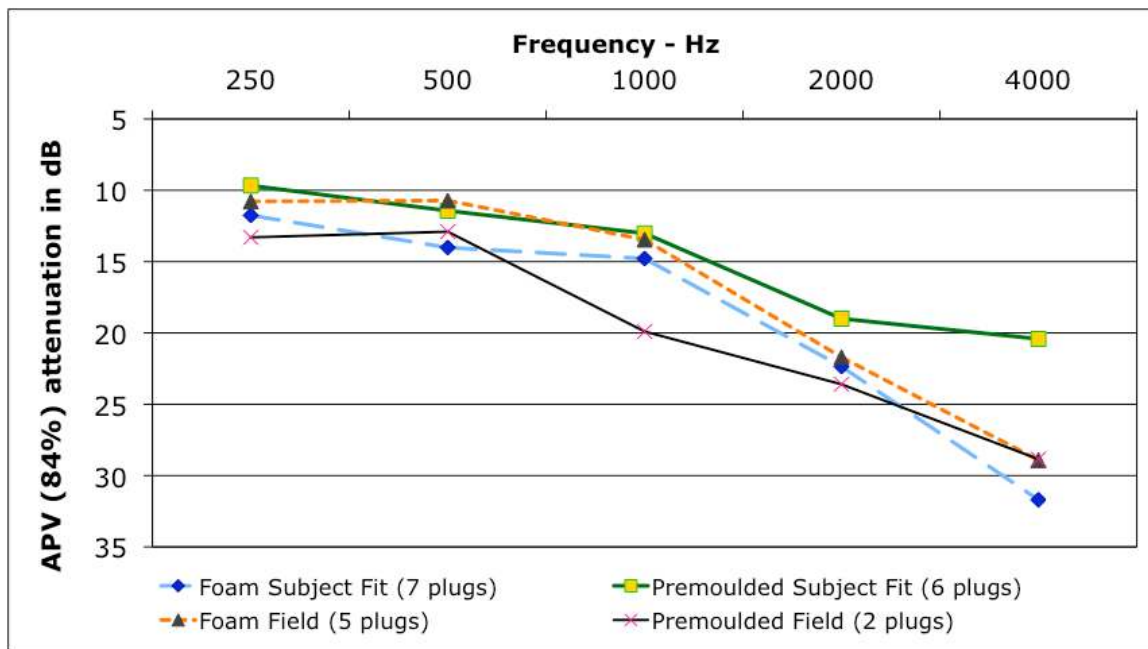


Figure 8-2. APV (84%) attenuation – average for foam and poulded plugs,

8.4. Relative attenuation by frequency

Figure 8-3 similarly shows the the relative mean attenuation by frequency for foam and premoulded plugs respectively. Data are averaged for all plugs of the same type (foam or premoulded).

The same observations apply: For the foam plugs, the relative attenuation is very similar for SF data and the german field study. For the premoulded plugs, the german field data are somewhat higher than the the subject fit data.

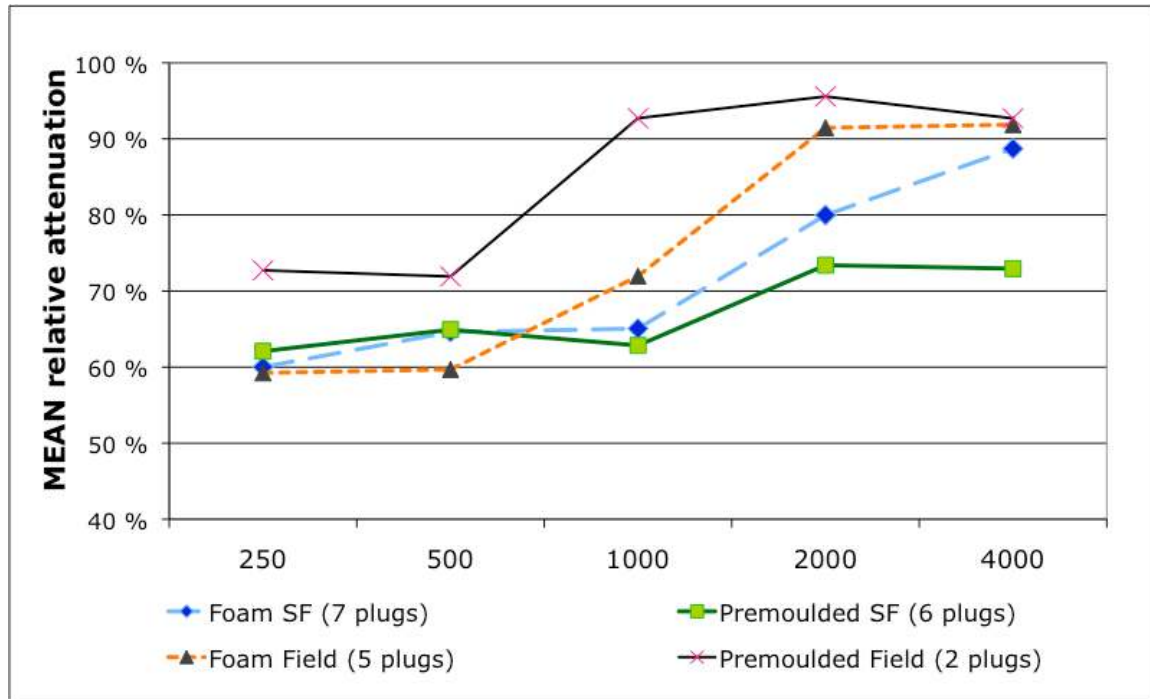


Figure 8-3. Shift of the mean attenuation by frequency, field vs ISO 4869-1 mean.

9. INDIVIDUAL TRAINING – WHAT CAN BE ACHIEVED?

Most specialists on hearing conservation will admit that some sort of real-world effect should be accounted for. However, opinions and recommendations vary considerably about how and *how much*.

Ear plug performance clearly has a lot to do with training and motivation. An important tool to improve the performance is to measure the attenuation by doing *individual fit testing*. Several commercial systems now exist to do this. Thousands of workers, particularly in North America, have been tested and trained. Figure 9-1 and 9-2 shows an example of what may typically be achieved through such an exercise.

Table 9-1 shows the broad-band attenuation (PAR=Personal Attenuation Rating) of the workers in a factory plant before and after training. In addition to providing individual training of the 100 or so workers, up to 9 plugs were available for the after results to try to achieve the best fit possible.

The attenuation values *after training*, turn out to be very similar to the other data sets presented in this document. A summary of approximate percentiles is presented in Table 9-1. The overall improvement achieved by the fit testing is 4-6 dB. The 10 percentile increased from about 9 to 13 dB, the 25 percentile from 15 to 20 dB.

This case proves that individual testing and training can significantly improve ear plug performance. However, it also reminds us that ear plug fitting is genuinely difficult for some.

Table 9-1. Personal Attenuation (PAR) values before and after individual fit testing

Percentile	10%	25%	50%	75%	90%
1 -Attenuation before [dB]	27	21	18	15	9
2- Attenuation after [dB]	34	27	23	20	13
Improvement [dB]	+7	+6	+5	+5	+4

10. DERIVING A LOW VALUE – FOR CALCULATING NOISE EXPOSURE

The main reason for using hearing protectors in the workplace is normally to ensure that individual noise exposure is kept under control and within legal limits. Consequently, the attenuation value that most users and supervisors are looking for is some "safe" low attenuation value that "everybody" can achieve.

Unfortunately, no such "safe" low value exists for ear plugs. A plug that leaks, simply may provide no attenuation. On an individual level, therefore, the attenuation of an ear plug is unknown. The only way to really find out, is to do individual training and verification, preferably measuring the attenuation. Very importantly, such testing will identify those who need follow-up, needing a different type of hearing protector (such as a muff or a custom moulded plug).

As we have seen, things are much more predictable on a statistical level. The data sets looked at here suggest that the achieved attenuation for the low performers is surprisingly predictable and largely independent of the label value of the products. In other words, it does not seem to make much difference for these users whether the label attenuation is 22 dB or 35 dB (but it most probably would if we had included one with 15 dB...).

From figure 7-2 a set of "field APV" (84%) values can be tentatively derived as shown in Table 10-1.

Table 10-1. Suggested field attenuation of generic full-block ear plugs (84 percentile)

Plug type	125-500	1000	2000	4000-8000
Foam or premoulded, full-block ear plug	12 dB	15 dB	20 dB	25 dB

In HML and SNR terms this becomes

- **L = 13 dB, M = 15 dB, H = 21 dB, SNR = 19 dB**

To repeat, the conditions behind these values are as follows:

- Users are trained and motivated (preferably including individual testing)
- A variety of different products and sizes are made available
- The products considered are "full-block" plugs with M values of 22 and more

Of course, these numbers are somewhat indicative. But they should represent a reasonable starting point of what most users should be able to achieve in the real world. They may be used as a realistic basis for setting up a hearing conservation program.

It may be possible in special cases to improve these values – if necessary. But it is likely to mean hard work – and probably the use of alternative hearing protectors for many users.

Indeed, a very important learning point from large-scale individual fit testing is that some 5-15% of users are very difficult to successfully fit with ear plugs. It is crucial to consider this when setting up a hearing conservation program. Usually, people struggling with ear plugs, are well aware of the problem themselves. Making at least one type of muff available as an alternative, is a simple measure which is highly advisable.

11. OFFICIAL LABEL VALUES

The findings of the previous section makes it tempting to dismiss the label values displayed on the packaging as irrelevant. This would, however, be to miss an important point.

Quite a few users do obtain the attenuation label values and more. And for these, it does make a difference what ear plug is chosen. Figure 7-1 in particular shows this.

The Flint data suggests that some 25-50% of users achieve or exceed the label "assumed protection values"(APV). The german data gives much the same result. The four soft PVC foam plugs (M=29-32) are close to 25% whilst the others (M=24-28) are closer to 50%.

In particular, the low-frequency attenuation of the foam plugs with the highest values are disappointing. Whilst their label values indicate an almost flat attenuation curve, i.e. independent of frequency, only some 20% of users seem to achieve this flatness in the real world.

Overall, for a broad-band spectrum it would seem that the *label mean attenuation* (rather than the "APV" 84% values) would be a reasonable approximation representing a 20-30 percentile of field users, as indicated in Figure 11-1 for the german field data.

12. SUITABLE ATTENUATION VALUES FOR CHOOSING PRODUCTS

The EN 458(2004) guideline makes the important point that a hearing protector should provide sufficient attenuation but not overprotect.

The lower action value of the EU noise directive is $L_{EX,8h} = 80$ dB. Based on this, it may be argued that the noise exposure to the ear should be within 70-80 dB. Lower exposures to the ear than 70 dB may be considered as overprotection. Overprotection may mean an unwanted feeling of isolation and also make speech and warning signals less audible. The issue of overprotection is particularly important at noise (exposure) levels up to 90 dBA.

For the products considered here, typical standard deviations for field users are 7-12 dB. This implies a lack of predictability which makes it unfeasible to fit even most users within a 10 dB band of attenuation. A large degree of overprotection is, then, quite inevitable.

In the choice of products it is still a good idea to target for, say, 75 dB to the ear. To identify products likely to do this (on average at least) one may use label values, but with a moderate

compensation for field effects. Such a compensation, often called a *derating* (of the label values) may be achieved by subtracting a fixed dB value or using a relative scaling.

The most common approach in Europe, is to use fixed dB values, possibly different for different types of hearing protectors. For instance, Germany recommends using a 9 dB subtraction for foam ear plugs, 5 dB for premoulded ones (and ear muffs). The UK, on the other hand, recommends to subtract 4 dB for all types of hearing protectors.

The german real-world recommendation is derived from a broad-band averaging (250-4000 Hz) of the *shift of the mean*. The numbers have been derived largely from their own field data studies. The resulting compensation may represent something like a 60-75 percentile (varying by product) of field attenuation for trained users.

Such a derating produces a reasonable marker to be used in the choice of suitable products, i.e. providing an attenuation that is likely to be sufficient but not too high. Such a derating should, however, *definitely not be interpreted as predicting a minimum individual attenuation value for all users*.

As shown throughout this document, a "proper" derating really should be frequency dependent, due to the relatively larger loss of attenuation at the lower frequencies. And although fixed deratings are simpler to use, a derating really should be relative, i.e. with an increasing derating by label value.

Based on the various information presented in this document, a tentative derating scheme based on the *shift of the mean* is shown in Table 10-2.

Table 10-2. Suggestion for relative scaling of label data – to reflect shift of the mean

Plug type	125-500	1000	2000 - 8000
Full-block ear plugs with M values of more than 20 dB	70%	75%	85%

The common belief that it is a good idea to opt for the highest-attenuating devices, hoping that some of the extra margin will drip on the low performers simply does not hold.

12. SUMMING UP

Ear plugs ultimately represent an unreliable barrier to noise. While most users are well protected by using standard foam or premoulded ear plugs, a minority of users find plugs difficult to fit and use. As a consequence, some may obtain very little or no protection.

The main purpose of this document has been to try to identify, if possible, some reasonable field value of ear plug attenuation, a value that "most users should be able to achieve or exceed".

The first condition that must be fulfilled is that users have been trained and are motivated. When this is the case (and in today's workplaces around the world this is certainly more the exception than the rule), the data for the different data sets considered here very much converge. It is found that what could be called the "field Assumed Protection Value" (84

percentile) is about 15 dB for broad-band noise (representing an M value in the HML system). If the noise is dominantly high-frequency, the attenuation is about 20 dB.

Subject-fit data correlate very well with field data for foam plugs. For premoulded plugs, the field data tend to be slightly better than the subject fit data, particularly at high frequencies.

As a group, the attenuation for the low performing users (percentiles 75-90) is *virtually the same for all plugs*. This is a major conclusion of this data investigation of full-block ear plugs with M-values in the range 22-35 dB.

Individual fit testing is crucial to identify the low-performers, who particularly needs extra training in fitting and finding a suitable product. For some, other products will be necessary (such as an ear muff or a custom moulded plug).

The official label values are a good marker of what attenuation the better performing field users will achieve. Label values can be used as a HIGH value, for instance when considering overprotection. The mean values from the type testing, rather than the APV (84%), may provide a good estimate of a field 20-25 percentile.

An important use of official attenuation values, is to identify products likely to have a suitable attenuation for a group of people. This means taking both underprotection and overprotection into account. When doing this, a moderate margin for real-world effects, should be taken into consideration. One way to do this is to subtract the expected shift of the mean between field and label data. The data investigated here suggests that a moderate derating scheme should be relative and frequency-dependent. For broad-band noise, a derating of 20-30% may be recommended.

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ENCLOSURE 1

Overview of ear plugs in the various studies

Table E-1. Foam (formable) plugs

	Model	L	M	H	Flint field	German field	Subj fit
Foam 1	North Decidamp	23	26	31	X		
Foam 2	Moldex Pura-fit	26	32	34	X		
Foam 3	HL Maxlite	31	32	32	X	X	X
Foam 4	Moldex Spark	31	32	34		X	X
Foam 5	3M EAR Classic	22	24	30		X	X
Foam 6	Bilsom 303	29	29	32		X	
Foam 7	HL Multimax	32	32	33		X	
Foam 8	HL Laser lite	31	32	34			X
Foam 9	HL Matrix Orange	22	25	31			X
Foam 10	HL Max	34	35	36			X
Foam 11	3M 1100	31	34	37			X

Table E-2. premoulded (reusable) plugs

	Modell	L	M	H	Flint	German field	Subj fit
Pre 1	HL Quiet	23	25	29	X		X
Pre 2	HL Air soft	25	27	29	X		X
Pre 3	3M EAR Ultrafit	25	28	33		X	X
Pre 4	Moldex Rockets	24	26	31		X	X
Pre 5	HL Smartfit	23	27	32			X
Pre 6	3M 1271	20	22	27			X