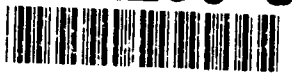
AL-TR-1992-0132



ARMSTRONG LABORATORY

MEASURING HEARING PROTECTION DEVICE PERFORMANCE USING THE METROSONICS db-3100 SOUND LEVEL ANALYZER (DOSIMETER)

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Brooks Air Force Base, TX 78235-5114

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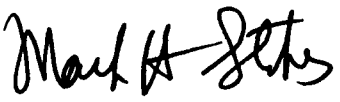

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Chief, Occupational Medicine Division

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This report provides detailed operating instructions to be used by base-level bioenvironmental engineers and technicians to determine appropriate personal hearing protection devices (HPD) and to calculate allowable exposure times for individuals wearing different HPDs in hazardous noise. In addition, this report presents a computer program that uses dosimeter time histories from Metrosonics noise dosimeters to streamline and increase the accuracy of HPD assessments.

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MEASURING HEARING PROTECTION DEVICE PERFORMANCE USING THE METROSONICS db-3100 SOUND LEVEL ANALYZER (DOSIMETER)

INTRODUCTION

Purpose

This report provides operating instructions for the Hearing Protection Device Assessment (HPDA) software to be used by base-level bioenvironmental engineering services (BES) to determine appropriate personal hearing protection devices (HPDs) and to calculate allowable exposure times for individuals wearing different HPDs in hazardous noise.

Problem

Historically, HPD assessments have been complicated because the base Bioenvironmental Engineer (BEE) is often faced with a multitude of noise sources, varying noise levels, and a myriad of hearing protectors available to reduce at-the-ear Sound Pressure Levels (SPLs) to an acceptable level. BES personnel have expressed difficulty in making an accurate HPD and noise exposure assessment. This program is designed to provide the flexibility to assess HPD effectiveness under conditions with multiple noise sources of varying noise levels using any Air Force approved HPD.

Scope

This report provides procedures and operating instructions for calculating at-the-ear SPLs and allowable exposure times to hazardous noise using Metrosonics Noise Dosimeters, an IBM-compatible microcomputer (i.e., Zenith Z-248), and the HPDA program. Procedures and operating instructions describe (1) programming the Metrosonics dosimeter, (2) downloading the data to an IBM-compatible computer, and (3) running the HPDA program.

DISCUSSION

The use of HPDs is the primary Air Force method for protection of personnel from hazardous noise when engineering or administrative controls are not sufficient to provide adequate noise reduction or are not feasible. Several methods have been developed to determine adequate hearing protection. The most accurate method, listed in AFR 161-35, Table 4 (1), as a function of the octave band, is based on the fact HPD attenuation is dependent on the frequency content of the noise source. The estimation of at-the-ear sound levels using this method requires the collection of octave band SPLs, subtraction of the HPD attenuation for each particular octave band, correction to A-weighting, and adding logarithmically to obtain the

total A-weighted SPL. This method is extremely time consuming and often requires equipment not available to the BEE. When octave bands cannot be collected, noise attenuation can be estimated from the A-weighted and C-weighted SPLs of the noise source. The C-A (C-weighted minus A-weighted) value provides a good approximation of the contribution of each frequency. The effective at-the-ear sound level is calculated by subtracting the HPD's noise attenuation value from AFR 161-35, Table 3, from the source's A-weighted sound level. This effective exposure level is used to calculate the allowable exposure time from AFR 161-35, Table 5. Even though this process is simplified from the octave band analysis, it can still be quite cumbersome when BES personnel are faced with multiple shops, multiple sources, and a variety of possible HPDs to use; therefore, the HPDA program was developed to simplify this process.

Originally, the program was designed to use the C-weighted and A-weighted values obtained from the DD Form 2214, Noise Survey (4) to assess HPD effectiveness. With the development of microphone splitter circuits, A-weighted and C-weighted data can be recorded simultaneously from one microphone. The original program (4) was modified to streamline the analysis and utilize noise dosimeter time history files, along with operator input, to determine how successfully a selected HPD can protect a worker under the conditions the dosimeters were worn.

PROCEDURES

Detailed operating instructions for the HPDA software can be found in the Appendix. The instructions are designed to provide the first-time user with illustrations of the display screens along with detailed explanations of user inputs. Please call the Noise Hazards Function at DSN 240-3214 or 240-2455 if you experience any problems with the software or want additional information concerning the program. We always eagerly solicit suggestions for improving the program to meet your needs.

General Guidelines

1. Set the internal clocks on all the dosimeters from the same computer so the times listed in the time history reports will match.

2. Typically, the period length can be set at 1-minute intervals. This period length can be adjusted if you prefer greater resolution of the time history. The limiting factor is the number of intervals the dosimeter can store in the time history (720 for the db-3100).

3. Since the program user can select a particular noise event from the time history for analysis, it is imperative the worker or BEE observing the worker keep a record of noise-producing events occurring during the run.

4. The Noise Hazards Function personnel placed the paired dosimeters on ammunition belts for easy attachment and removal from the workers (2). This arrangement does not impede the workers; it keeps the dosimeters together and drastically reduces attachment/removal times. The dosimeters can be programmed or downloaded while still on the belt.

Setting Dosimeter Times

The HPDA program can use either one or two time history files as input; however, if only one is used, the C-A value must be provided by the operator. If two dosimeters were run simultaneously, the C-A value is determined by the program using both time histories. At present, HPDA software is set up to use time histories from Metrosonics dosimeters. Other manufacturers have recognized the need to determine the A-weighted and C-weighted levels simultaneously and may offer dosimeters capable of recording both weighted values in the future; however, this program will **only** accept data from Metrosonics dosimeters.

NOTE: The program will also work with the db-310 dosimeter; however, the db-310 **does not** have the ability to record C-weighted data. You must supply the C-A value.

When using the db-3100 dosimeters in pairs, it is helpful to perform a test run first to synchronize start times. These dosimeters sometimes start recording data 1 to 3 seconds after the programmed start time. We recommend you pair together dosimeters having the same delay so they can be set for the same start time and sample during the same period. It is also possible to stagger the programmed start times to cause a mismatched pair of dosimeters to start simultaneously.

Signal Splitters

Microphone signal splitters are available from Metrosonics, Inc., Box 23075, Rochester, NY 14692. The splitters may not be listed in the current literature, but they may be ordered using part number ca-3100s. Contact Mr. Kenneth Burke, at (716) 334-7300, 1-800-654-7778, or FAX (716) 334-2635 for a current price quotation.

HPDA Software

The HPDA software is available on the Pegasus Electronic Bulletin Board System (formerly the Electronic Information Exchange System), Brooks Air Force Base, TX, by dialing toll free 1-800-582-0365 anywhere in the CONUS, Alaska, Hawaii, Puerto Rico, and the Virgin Islands or (210) 536-3784. The software is also available on diskette through requests to the Noise Hazards Function, AL/OEMI at DSN 240-3214 or 240-2455.

Downloading Data

When sampling is complete, the time history data should be downloaded to a computer as soon as reasonably possible. The db-3100 software allows quite a bit of information to be stored with the downloaded file (test location, employee name and number, comment fields, etc.), but then it stores all reports in files with consecutive numerical filenames (i.e., 31001, 31002, and so forth). The HPDA program only uses the time histories for calculations, so it will be necessary to save this part of the report separately from the original archived files. When saving the time histories, you can name the file with an eight-character alphanumeric code. Using some sort of consecutive file designation for an individual will make it easier to run the program. Consult the operator's manual for specific downloading, archiving, and analysis procedures (3).

RECOMMENDATIONS

Use the Hearing Protection Device Assessment software and dosimeter time histories to calculate HPD effectiveness and determine allowable exposures when HPDs and time limits are necessary to control worker exposure to hazardous noise.

REFERENCES

1. AFR 161-35, Hazardous Noise Exposure (9 April 1982).

2. Johnson, P. T. A User's Guide to the Armstrong Laboratory Electronic Information Exchange System (EIES Electronic Bulletin Board), Brooks AFB TX. AL-TR-1991-0053, April 1991.

3. Metrosonics ms-935 Metrosoft for the db-3100 Sound Level Analyzer, Metrosonics, Inc., Rochester NY, Part Number 935-200-003 REV C.

4. Schleifer, John G. and Fairman, Terry M. Assessing Hearing Protector Device Performance and Calculating Allowable Exposure Durations in Hazardous Noise, Armstrong Laboratory, Brooks AFB TX. AL-TR-1992-0026, April 1992.

APPENDIX

Hearing Protection Device Assessment Operating Instructions

HEARING PROTECTION DEVICE ASSESSMENT

OPERATING INSTRUCTIONS

NOTE 1: The program must be run with a color monitor.

NOTE 2: The program is designed to use Metrosonics dosimeter data only.

NOTE 3: Entries can be made as uppercase or lowercase letters.

1. Locate the file named HPDA.EXE. Make the drive where this is found the default drive; then type "HPDA" and hit "ENTER".

2. An introductory screen will be displayed, followed by a title screen. When prompted to "Hit any key to continue", hit any standard key (letter, number, space bar, or ENTER key) to proceed with the program.

3. The program displays the current date (Fig. A-1) taken from the computer and provides the user with an opportunity to "Reset Current Date". Hit "Y" and "ENTER" to change the date, or "N" and "ENTER" to leave the date as displayed. Since this date may be used to record when certain files were created and also displayed in various program outputs, it is important to have the correct date available.

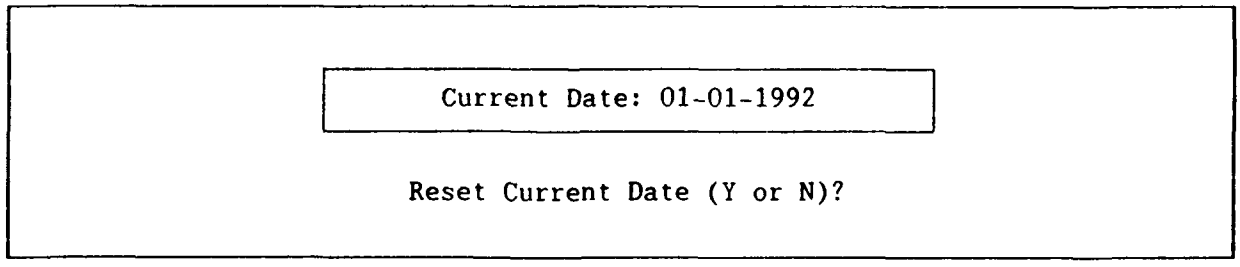

Figure A-1. Current Date Screen.

4. Select the disk drive where the data is stored (Fig. A-2). If, for example, the data files were on a diskette in drive B:, the user would hit "B" and "ENTER". It is not necessary to include the colon. The drive specified here can be referred to as the data drive.

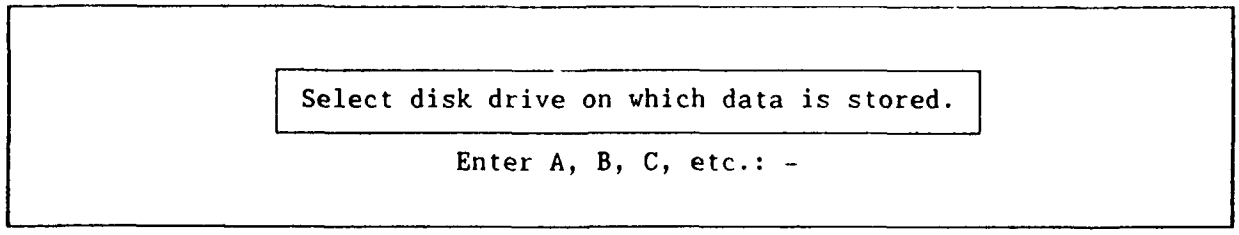

Figure A-2. Disk Drive Selection Screen.

5. The "DATA FILES DISPLAY" screen (Fig. A-3) is designed to allow you to look at lists of files on the data diskette. The F1 through F4 keys are used to display lists of all files with the particular extension as indicated on the screen. F5 allows you to specify the extension to be listed. When prompted, type the extension (may include question marks) or use an asterisk to get a listing of all files on the data disk. Once you find the name of the input file to use, press F6. The extension **MUST** be included when entering input file name; however, the drive does not have to be included unless it is other than the data drive previously specified in step 4.

NOTE: Multiple lists of files can be displayed simultaneously.

```
                          DATA FILES DISPLAY
  For files on diskette in drive A:, select the extension for the files
  you wish to display.  Use the function keys to make your selection.
 PRN 3

FILE1AWT.PRN      FILE1CWT.PRN      FILE2AWT.PRN      FILE2CWT.PRN
FILE3AWT.PRN      FILE3CWT.PRN
 540672 Bytes free




 1 DAT  02 TPF  03 PRN  04 HPA  05 Other 06 Quit 07     08     09      0
```

Figure A-3. Data Files Display.

6. The "FILE INFORMATION" screen (Fig. A-4) lists the information pertaining to the file you selected in step 5 and an input block for inputting, deleting, or changing file information. The "Subject Name:" line will not initially identify the test subject. If you used a Metrosonics db-3100 dosimeter and entered a test subject name before the dosimeter data was downloaded, this subject name will appear in the input block (titled "Dosimeter File Subject:") at the bottom of the screen. You may accept this name, change the name, enter any appropriate name not previously entered, or leave "subject name" blank if none is available. If you choose to change the subject name, type in the new name in the black input boxes. When the new name is entered, it is moved up to the list of file information and a subsequent input box appears for entering a noise source. Once entered, the noise source information is also added to the list of file information.

7. Next, enter the "Lower dB Selection Limit" and "Upper dB Selection Limit". These limits are used to define a "Default Lav Range". The program will flag all intervals where the average sound pressure level (SPL) falls within the default range. This information may be helpful in identifying noise from a particular source, or it can be used to call attention to any interval during which the average SPL was greater than a given level. After the upper limit is entered, there will be a delay of several seconds while data is read into the program as indicated by the flashing "Working!" message.

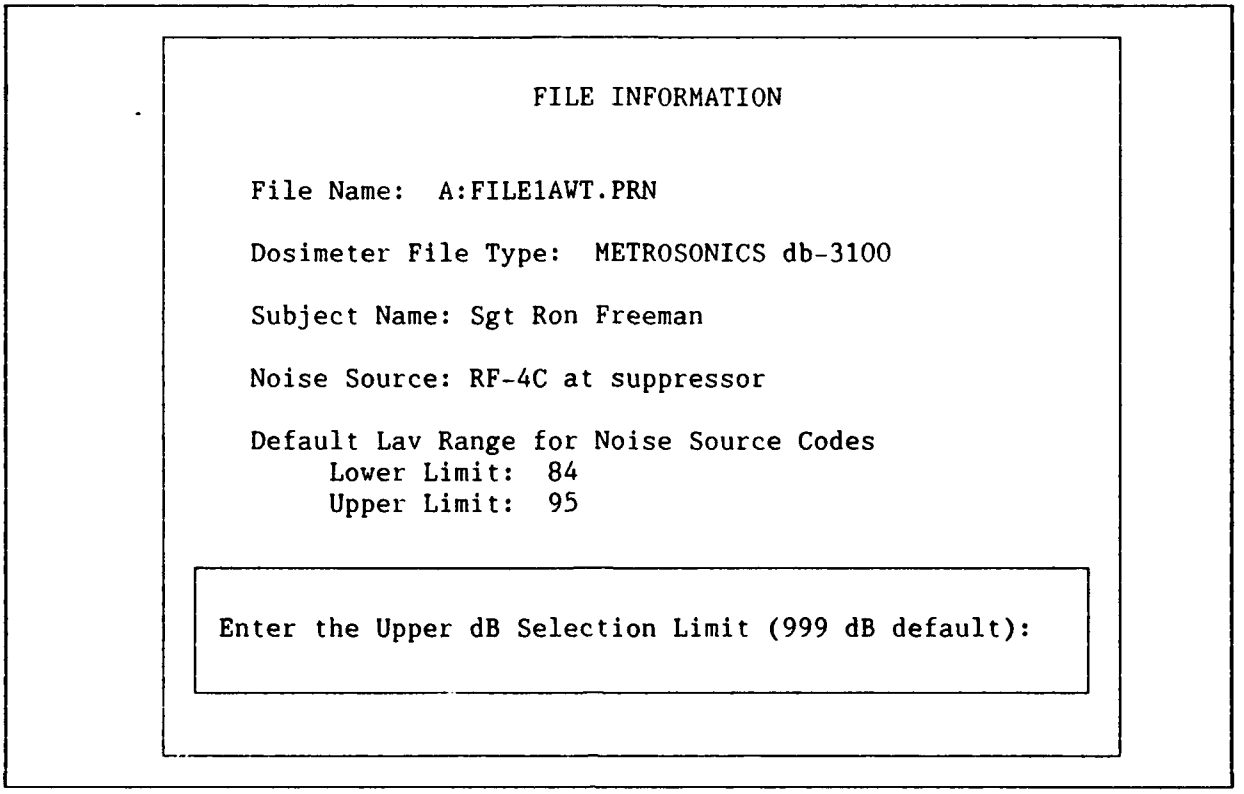

Figure A-4. File Information Screen.

8. If you used a second db-3100 dosimeter to collect C-weighted data, you must enter the file name (including extension) containing the C-weighted data; otherwise, this screen is bypassed. Once the file name is entered, the file reading process is repeated.

NOTE: File extension must be included when specifying C-weighted file.

9. The "Noise Source Definition Screen" (Fig. A-5) allows you to enter a 40-character description for each noise source of interest and a corresponding one-character code. For example, if the dosimeter was worn during a jet engine test run, the user might want to list each power setting for the engine as a separate source. The single character code entered for each noise source must be unique. Any alphanumeric character (most other symbols are also acceptable) can be used as a noise source code.

NOTE: "X" is automatically assigned to internals within the default range specified in step 7.

NOISE SOURCE DEFINITIONS

Type in a brief (40 characters max) description of a noise source which can be clearly identified in the time history for file 'A:FILE1AWT.PRN'. Then choose a single character alphanumeric code to correspond with the noise source description. Push 'Enter' without an entry to exit table.

	NOISE SOURCE DESCRIPTION	CODE
1	DEFAULT Lav RANGE: 84 <= Lav <= 95	X
2	Engine at Afterburner	A
3	Engine at Military Power	M
4	Engine at 80%	8
5	Engine at Idle	I
-> 6		

Figure A-5. Noise Source Definition Screen.

10. If an error is made when entering a noise source description, it is not possible to backspace or delete characters to make a correction. Instead, enter the erroneous description and code without making an entry for the next noise source description. When asked "Are all entries correct (Y or N)?" select "N" and "Select line number for correction" by entering the line number (left-hand column) of the erroneous entry. The cursor returns to the noise source description for that line, which has now been blanked out, and the erroneous entry is displayed in the prompt area beneath the table for reference. Enter the noise source description correctly and confirm the associated code. If there are more noise source descriptions to be entered, continue as before. When all noise source descriptions and codes have been correctly entered, hit "ENTER" to exit the table.

11. If you desire a noise code listing printout, enter a "Y" when prompted in Figure A-6. The noise source descriptions and associated codes entered in Figure A-5 will be printed.

DO YOU WANT A NOISE SOURCE CODE LISTING?

Figure A-6. Noise Source Code Listing Screen.

12. You can request a current time history printout by entering a "Y" in Figure A-7. A listing of time history information from the dosimeter can be sent to the printer, diskette, or both (see Fig. A-8). The printout includes a column for noise source codes. At this point only "X"s will appear for intervals where the average SPL was within the default range set in step 7. Nulls appear for all other intervals. If you enter an "N", the program proceeds to the edit screen (Figures A-9 and A-10).

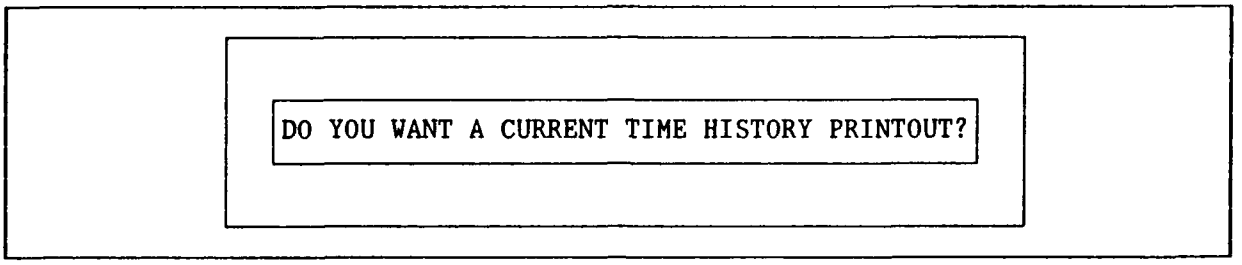

Figure A-7. Time History Printout Screen.

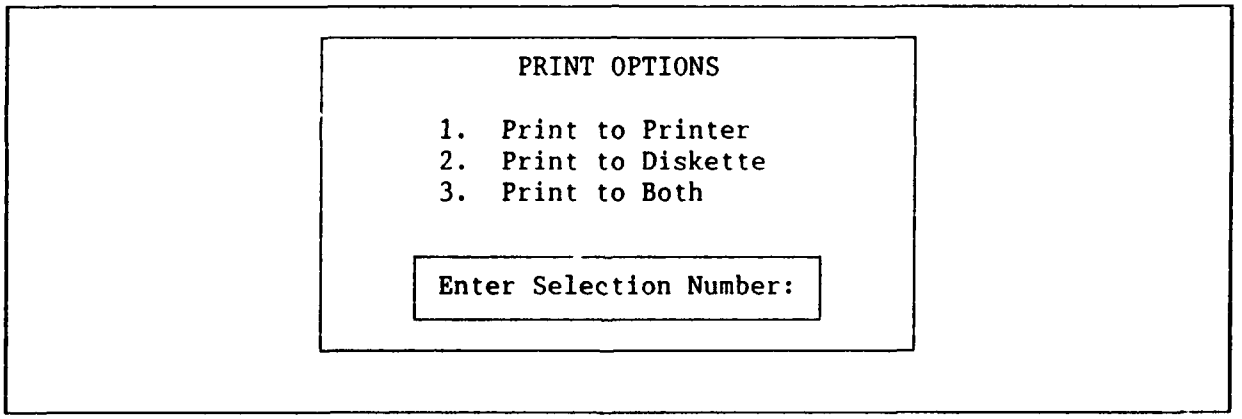

Figure A-8. Print Options Screen.

13. Figures A-9 and A-10 are used to assign the appropriate noise source code to each interval of the time history, allowing you to indicate what operation was taking place during each interval, so each operation can be analyzed separately. On the left side of the edit screen (Fig. A-9) is a window displaying a portion of the time history. This shows the interval number (INT), the time the interval began (TIME), the average A-weighted SPL during the interval (La), the average C-weighted SPL during the interval if C-weighted data was also taken (Lc), and the noise source code for intervals where a code has been assigned.

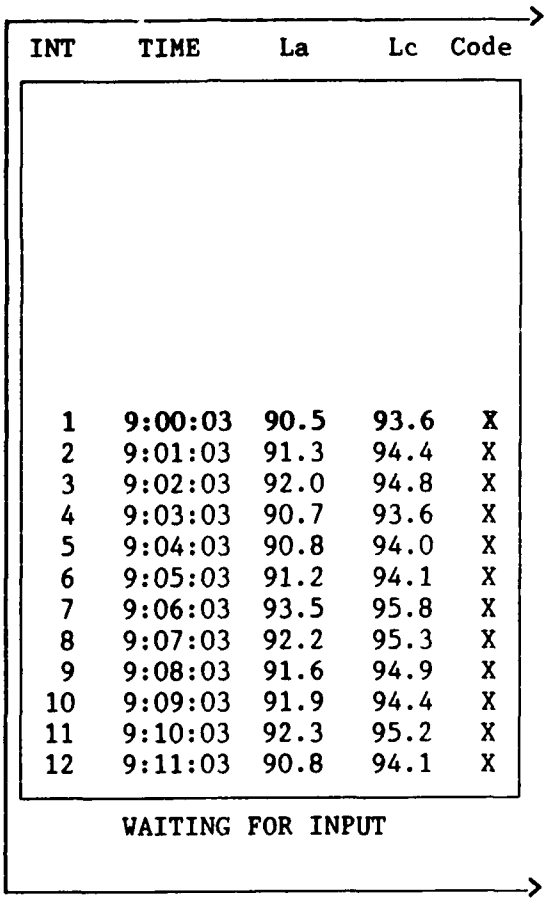

Figure A-9. Time History Window
Left Side of Edit Screen.

The upper portion of the right side (Fig. A-10) of the edit screen displays information about the file from which the time history was extracted which includes: (1) name of the subject, (2) the primary noise source, (3) the dosimeter manufacturer, model, and serial number, (4) the date measurements were taken, and (5) the archive date if the time history was previously edited and archived. Below the file information is a listing of the color schemes and commands used in the time history window. Below is an expanded explanation.

a. **Gray** - is used to identify intervals where a noise source code has been set (including intervals where the SPL is within the default range).

b. **Blue** - is used for intervals which have not been assigned a source code.

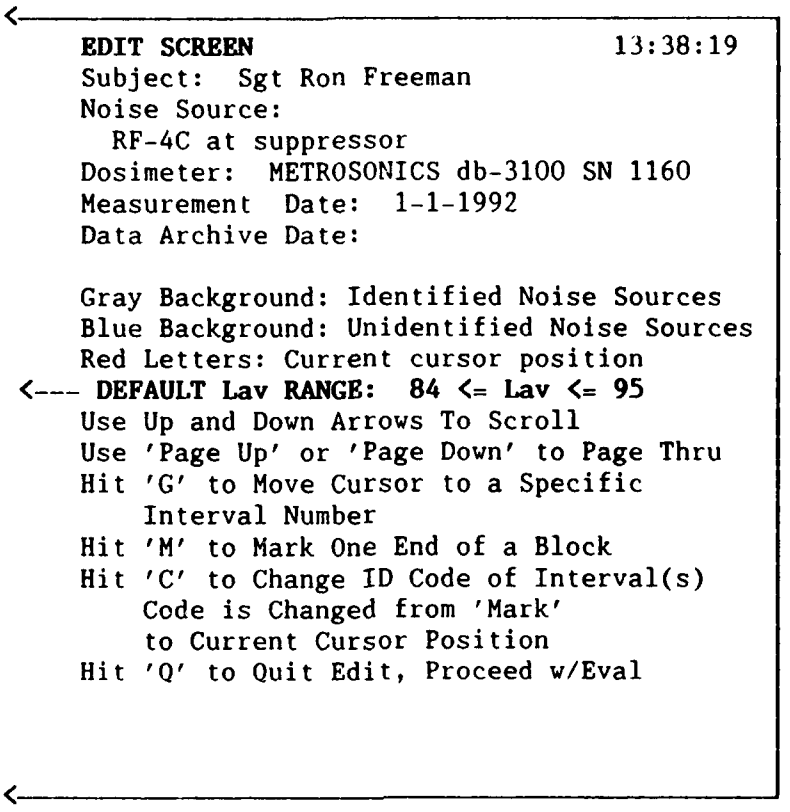

Figure A-10. Time History Window
Right Side of Edit Screen.

c. **Red Letters and Arrow** - points to the interval occupying the current cursor position (also marked with red letters). To the right of the arrow is the noise source description corresponding to the noise source code assigned to the interval in the current cursor position.

d. **Up and down arrows** - move the time history window on the left side of the screen **ONE** line at a time.

e. **"Page Up"** and **"Page Down"** - move the time history window **18** lines at a time.

f. **"G"** - is used as a "Goto key". When you press "G", the program asks for an interval number to go to. When this interval number is entered, the window is moved so the specified interval is in the cursor position.

g. **"M"** - is used to mark one end of a block of consecutive intervals which are assigned the same noise source code. The cursor is placed at the first (or last) interval to be included in the block. When the "M" is pressed, one end of a block is determined (marker position). Notice the bottom of the screen displays the interval that has been marked. Use the cursor controls described above to position the cursor at the opposite end of the block (cursor position).

Once the cursor has been moved to this position, press "C" and enter a noise source code. This code is assigned to each interval in the block, from the marker position to the cursor position. Uppercase and lowercase letters are treated as **different source code entries**. Inputs must correspond exactly with the source codes defined in Figure A-5.

NOTE: To change the noise source code for a single interval, omit setting the marker. If no marker is displayed when "C" is pressed, the noise source code will be changed only for the interval in the cursor position.

h. **"C"** - Changes interval code

i. **"Q"** - Ends the source code editing session. When all necessary changes have been made to the noise source codes, press "Q" to exit editing and proceed with the evaluation.

NOTE: For the entries "G, M, C, and Q", either uppercase or lowercase letters can be entered.

14. Once again, after leaving the edit screen, you can print the time history with the noise source codes. This printout will include all changes made in the edit screen.

15. If you enter a "Y" when the "ARCHIVE TIME HISTORY WITH NOISE SOURCE CODES?" screen appears (Fig. A-11), the time history, including the noise source codes entered from step 13, are saved in a file with the extension ".ARC" on the diskette in the data drive.

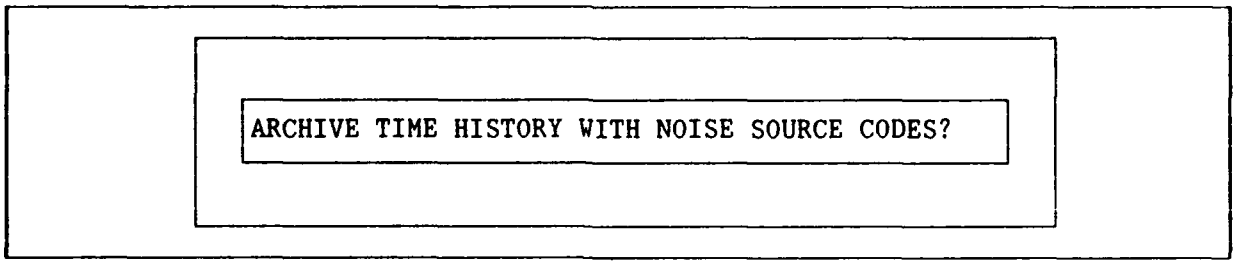

Figure A-11. Archive Prompt Screen.

16. The "NOISE SOURCE SELECTION SCREEN" (Fig. A-12) allows you to select which of the identified noise sources to include in the assessment. Any combination of these noise sources may be used for a given assessment. Find the left arrow in the "MARK TO INCLUDE" column. If the noise source described on the left side of the same line in the table is to be included in this assessment, hit the capital "X". If it is not to be included, hit "Enter". The arrow will move down the table, so you can decide whether to include or exclude each source. When complete and asked if "Selections correct (Y or N)?", enter an "N" to reset the marks; otherwise, enter "Y" to proceed to Figure A-13.

NOISE SOURCE SELECTION SCREEN

Select the identified noise sources to use for this HPD assessment. Any combination of identified noise sources may be used. To make the selection, enter a capital 'X' under the 'MARK TO INCLUDE' column of the table. Use 'Enter' without an entry if you do not want to include the noise source. Only the capital 'X' and 'Enter' keys will operate.

NOISE SOURCE DESCRIPTION	CODE	MARK TO INCLUDE
DEFAULT Lav RANGE: 84 <= Lav <= 95	X	X
Engine at Afterburner	A	X
Engine at Military Power	M	
Engine at 80%	8	
Engine at Idle	I	<-

Figure A-12. Noise Source Selection Screen.

17. Figure A-13 is used to "SELECT HEARING PROTECTION DEVICES" listed in Table 3, Single Number Attenuation Factors (dB(A)), in AFR 161-35, Hazardous Noise Exposure. The attenuation values used by the program were obtained from this table. You are not limited to evaluating the effectiveness of the hearing protector actually used. You can select any of the Air Force approved hearing protection devices to be evaluated for the designated noise source.

SELECT HEARING PROTECTION DEVICE

QPL Muffs (configured over the head)

1. Amer. Optical 1720 SD
2. MSA Mark IV MC
3. Willson 365
4. Marion Sound Stifler
5. Bilsom UF 1
6. David Clark E-310

Inserts

7. V-51R
8. Flents
9. Comfit (triple flange)
10. E-A-R
11. PROPP-O-PLAST (US Mil config)

Helmets

12. HGU-2A/P with 17P liner
13. HGU-26/P with custom liner
14. HGU-39/P
15. DH-151
16. HGU-26/P with MX8376/AR earcups

Communications

17. H-133 (ground)
18. H-157 (in-flight)
19. H-133 (w/custom molded insert)

Combination

20. QPL Muff and Inserts (V51 or EAR)

Enter the number of the hearing protector to be evaluated?

Figure A-13. Hearing Protection Device Selection Screen.

18. If a second dosimeter was used to take concurrent C-weighted data, the computer automatically determines the C-A value needed to determine the attenuation value for the selected hearing protector. If the second dosimeter was not used, you must determine the C-A range. The range can be determined either from sound level meter data or extracted from the DD Form 2214, Noise Survey. Select A through E on the screen titled "C-A VALUE INPUT" (Fig. A-14) to determine the appropriate hearing protector attenuation value.

C-A VALUE INPUT

A. -2 thru 0
B. 1 thru 3
C. 4 thru 7
D. 8 thru 12
E. 13 and up

Enter letter corresponding to C-A Value?

Figure A-14. C-A Value Input Screen.

19. The "HEARING PROTECTION ASSESSMENT/ALLOWABLE EXPOSURE TIME" screen (Fig. A-15) displays the results of the assessment. The first block displays the basic information about the assessment drawn from the dosimetry file or user input. The second block (indented) displays results in time units or dBA as described below.

```
            HEARING PROTECTION ASSESSMENT/ALLOWABLE EXPOSURE TIME

Subject.................:  Sgt Ron Freeman
Test Date / Archive Date.:   1-1-1992 /
Dosimeter...............:  METROSONICS db-3100 SN 1160
Noise Source............:  RF-4C AT SUPPRESSOR
Hearing Protection Device:  H-133 (mod w/custom molded insert)
C-A Value...............:  2
Selected Noise Codes.....:  X
    Total Minutes Actual Exposure Time.....:    81.0 min
    Average Sound Exposure Level ( 4 dB)...:    98.6 dBA    100.7 dBC
    Hearing Protector Attenuation..........:    29.0 dBA
    Effective at Ear Exposure..............:    69.6 dBA
    Total Allowed Exposure Time............:  5870.6 min ( 97.8 hrs)
    Allowed Time Minus Actual Exposure Time:  5789.6 min *

*   All positive numbers represent adequate hearing protection (HP)
attenuation values. Positive numbers also represent the time remaining before
the allowed exposure time is exceeded, and alternative controls are required.
All negative numbers represent inadequate HP attenuation values.  Negative
numbers also represent the minutes the allowed exposure time is exceeded. If
the number is negative you must either (1) enforce the total allowed exposure
time; (2) evaluate another HP device; or (3) incorporate additional
administrative controls.
Print Summary?
```

Figure A-15. Assessment Results Screen.

a. **Total Minutes Actual Exposure Time** - is the total time for all intervals with the selected noise source codes

b. **Average Sound Exposure Level** - is the average A-weighted sound level computed for only the selected intervals. If C-weighted data was also taken, the C-weighted average is displayed just to the right of the A-weighted average.

c. **Hearing Protector Attenuation** - this value depends on which hearing protector was selected and the C-A range.

d. **Effective at Ear-Exposure** - is the SPL actually experienced by the ear after the HPD attenuation is factored in.

e. **Total Allowed Exposure Time** - is the amount of time an individual can be exposed at the effective at-ear exposure level.

f. **Allowed Time Minus Actual Exposure Time** - If this value is greater than zero, it means that the hearing protection was adequate, and this is the amount of time an individual could continue this exposure without being overexposed. If this value is less than zero, it means the hearing protection was not adequate, and this is the amount of time the exposure exceeded the allowed exposure time. In case of overexposure, it is necessary to enforce the total allowed exposure time, evaluate another hearing protection device, or incorporate additional administrative controls.

20. Finally, there is a prompt asking, "Print Summary?". If you enter "Y", a summary is printed in much the same format as displayed on the screen. By entering "N", Figure A-16 appears. You can perform additional assessments, as described below, by selecting the appropriate number. This number will return you to different portions of the program. Select "0" to exit.

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                        Select Option

1 - New C-A Attenuation Factor          4 - Add or Change Noise Source Codes
2 - New Hearing Protector Device        5 - New Noise Dosimetry File
3 - Reset Selected Codes                0 - Finish

                      Enter Selection Number:
```

Figure A-16. Option Menu.

a. **New C-A Attenuation Factor** - if the C-A range was entered manually, this option returns you to Figure A-14 and allows you to repeat the assessment using a different C-A range.

b. **New Hearing Protector Device** - returns you to Figure A-13 and allows you to repeat the assessment for a different hearing protector. If, for example, an overexposure was found using one protector, the assessment could be repeated using a different protector or double protection to see if the overexposure could be prevented by changing hearing protection.

c. **Reset Selected Codes** - returns you to Figure A-12 and allows you to select a different combination of noise source codes, so the assessment can be made for a different set of conditions.

d. **Add or Change Noise Source Codes** - returns you to Figure A-5 where noise source descriptions and codes were assigned. New sources can be added, or old ones can be redefined or broken into components.

e. **New Noise Dosimetry File** - returns you to Figure A-3 and allows you to select another dosimetry file.

f. **Finish** - Exit program.

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