HETA 90-0281-2319
MAY 1993
SQUARE D COMPANY
OXFORD, OHIO

NIOSH INVESTIGATORS:
RANDY L. TUBBS, Ph.D.
CURTIS W. SIZEMORE
JOHN R. FRANKS, Ph.D.

## I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the Square D Company in Oxford, Ohio to evaluate their employees' occupational noise exposures in conjunction with the use of personal radio headsets on the job site. One portion of the request concerned the applicability of employees using a radio headset over plugged ears in areas requiring hearing protection. A procedure that measured the electrical output to the two earphones of a radio was developed by NIOSH for use in the field, that allows investigators to bring information back to NIOSH Division of Biomedical and Behavioral Science Laboratories for the completion of the analysis of the sound levels produced by the employees' radios.

Investigators from NIOSH conducted a noise evaluation at the Square D Company on April 23-24, 1991, and May 20, 1991. The electrical outputs from 22 radios belonging to employees were also measured during the survey. Similar radios were purchased by NIOSH to complete the analysis of the sound level output from the devices. Employee noise exposures measured with noise dosimeters revealed a median 8-hour time-weighted average (TWA) noise exposure of 84.6 decibels on an A-weighted scale [dB(A)]. One full-shift noise sample exceeded 90 dB(A), the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL). The noise dosimeter data did not include any estimate of the contribution of the personal radio headsets.

The procedure used to assess the impact of the radios found that all six brands tested in the laboratory exposed workers to potentially hazardous noise levels when listening to rock music programs and five of the six were potentially hazardous when listening to easy listening programs. None of the workers were exposed to hazardous levels when the radios were tuned to talk radio programs at settings initially found that had been selected by the user. All but one of the radios tested is capable of producing hazardous noise levels if the volume controls are rotated to the full setting for most program formats.

Because 50% of the TWA noise exposures equaled or exceeded the NIOSH Recommended Exposure Limit (REL) of 85 dB(A), NIOSH investigators determined that a potential for employee exposure to excessive noise exists at the Square D Company. The company should continue with its hearing conservation program that was in place at the time of the survey. Also, the potential for excessive noise produced by personal radio headsets turned to full volume should lead the Square D Company to educate the employees on the hazards associated with the devices.

Keywords: SIC 3613 (Electric Transmission and Distribution Equipment, Switchgear and Switchboard Apparatus), noise, personal radio headsets, hearing conservation programs.

## II. INTRODUCTION

On April 23-24, 1991, and May 20, 1991, investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted noise surveys at the Square D Company in Oxford, Ohio. The surveys were the result of a management request in May, 1990, that NIOSH conduct a Health Hazard Evaluation (HHE) at the electrical distribution equipment manufacturing facility. Specifically, the management officials at the Square D Company were concerned about the combination of noise produced in the manufacturing process, and the use of personal radio headsets by employees at their work stations. They also asked NIOSH investigators to comment on the use of the headsets by employees who were required to wear hearing protection devices (HPDs) because of the noise levels in the work area.

Difficulties encountered with a previously developed field method for measuring the sound levels produced by radio headsets in the workplace[1], delayed the noise surveys at the Square D Company. Subsequently, the NIOSH Division of Biomedical and Behavioral Science (DBBS) developed a more reliable method for obtaining radio headset noise levels in the field. NIOSH letters dated August 15, 1990, and January 29, 1991, provided updates on the method development. The preliminary results of the noise dosimetry were provided by a letter dated May 31, 1991. The laboratory portion of the evaluation was completed by DBBS and provided to the Project Officer on December 4, 1992.

## III. BACKGROUND

The Square D Company assembles electrical distribution products at its Oxford, Ohio facility. Metal stamping, metal machining, and assembly are the major operations of approximately 400 employees at the plant. The company has a hearing conservation program which includes the posting of areas where HPD use is mandatory, noise monitoring programs, and an audiometric testing program.

During a recent annual audiometric test, an employee raised the issue of using personal radio headsets over company-furnished earplugs with the audiometric technician. The technician tested the output of a radio headset with a sound level meter in a manner that would not accurately measure the output of the headset. The management of the Square D Company requested that NIOSH conduct the test of radio headsets in a more rigorous manner.

## IV. MATERIALS AND METHODS

The noise dosimeters used in the survey were Metrosonics Model dB301/26 Metrologgers, small noise level recording devices which are worn on the waist of the employee with a 1/4 inch microphone attached to the worker's shirt on the shoulder area. The dosimeters are designed to measure noise in decibels, A-weighted levels (dB[A]) four times per second. The noise measurements are integrated according to the Occupational Safety and Health Administration (OSHA) noise regulation for an entire minute and stored separately in the Metrologger for later analysis and final storage. Each dosimeter was calibrated according to the manufacturer's instructions before being placed on the worker.

After the recording period was completed, the dosimeters were removed from the worker and placed in the standby mode of operation. The data were later transferred to a Metrosonics Model dt-390 Metroreader/Data Collector following the day's noise sampling. Prior to turning off the dosimeters, they were again calibrated to assure that they had not changed during the sampling period. The dosimeter information in the Metroreader/Data Collector was finally transferred to a Personal Computer with supporting Metrosonics Metrosoft computer software for permanent data storage and analysis.

The original approach to evaluate the influence of the personal radio headsets on employees' noise exposures was to replicate a method that had been reported in the literature.[1] The method involved the use of the Knowles Electronic Manikin for Acoustic Research (KEMAR), a device used to simulate the acoustical properties of the human ear and the average anatomical dimensions of the head and upper body. An attempt by NIOSH investigators to use KEMAR showed that the measured acoustical output of the personal radios was very dependent upon the placement of the headphones over KEMAR's ears. It was decided that this method may be too variable for field applications. A protocol which uses the electrical output of the radio in the field, and the conversion of the electrical outputs to acoustical levels in the laboratory, was developed by investigators from the Physical Agents Effects Branch (PAEB), DBBS, NIOSH.

The field/laboratory approach measures the voltage applied to the headphones of the radio or tape player through an in-line adaptor placed between the headphone jack and the headphone plug. A separate lead attaches to a portable voltmeter and an A/B switch permits reading of the voltage for the left and right ears separately. A schematic diagram of the field measurement equipment is shown in Figure 1.

Workers at the study site were asked to remove their personal stereo earphones and not touch the volume control of their music players (radio or tape). The earphones were disconnected from the player and reconnected through a device interface which NIOSH developed to give a reading of the voltage input into the earphone at normal impedance load. Voltages were recorded at the user volume control setting, at 1/3, 2/3 and full volume control rotation. The earphones were reconnected to the player and returned to the worker. The type of program to which the worker regularly listened was also noted and labeled as country, rock, easy listening, or talk radio.

Supra-aural earphones similar to those used at the work site were purchased by NIOSH. The earphones evaluated were: Sony F2015; GE 702; Sharp JC5100; Panasonic GRF4230; Sony SR290; and Sony W2011. Earphones were placed on KEMAR at the DBBS laboratories and driven by a pink noise signal (noise with equal energy in every octave band) at 1.0 volts root-mean-squared (rms). The 1/3-octave-band levels were determined for both the right and left earphone and three samples were taken for each model. The 1/3-octave band levels for each earphone were logarithmically averaged across right and left ear samples. These averages were then converted to their free-field equivalent level using correction factors published by Bentler and Pavlovic (Ear & Hearing, 13(4) 285-286).[2]

Spectral characteristics had been obtained for many types of radio programming, including talk, easy listening, country, and rock. These spectra were then normalized to 1000 Hz. Only those spectra for talk, easy listening, and rock were used in the analysis because of the earphones purchased for testing. A free-field equivalent spectrum was calculated for each earphone for each type of program. The dB(A) level was then calculated for the four volume control settings: user; 1/3 rotation; 2/3 rotation; and full rotations.

## V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to ten hours a day, forty hours a week for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are the following: 1) NIOSH Criteria Documents and RELs, 2) the U.S. Department of Labor, OSHA PELs, and 3) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs).[3,4,5] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH-recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that employers are legally required to meet those levels specified by an OSHA PEL.

### Noise

Occupational deafness was first documented among metalworkers in the sixteenth century.[6] Since then, it has been shown that workers have experienced excessive hearing loss in many occupations associated with noise. Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells

of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[7]

While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist", have still higher frequency components.[8]

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[9] specifies a maximum permissible exposure limit (PEL) of 90 dB(A)-slow response for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure level must be cut in half in order to be within OSHA's PEL. Conversely, a person exposed to 85 dB(A) is allowed twice as much time at this level (16 hours) and is within his daily PEL. Both NIOSH, in its Criteria for a Recommended Standard,[10] and the American Conference of Governmental Industrial Hygienists (ACGIH), in their Threshold Limit Values (TLVs),[11] propose an exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard. Both of these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

Time-weighted average (TWA) noise limits as a function of exposure duration are shown as follows:

| Duration of Exposure (hrs/day) | Sound Level [dB(A)] NIOSH/ACGIH | OSHA |
|---|---|---|
| 16 | 80 | 85 |
| 8 | 85 | 90 |
| 4 | 90 | 95 |
| 2 | 95 | 100 |
| 1 | 100 | 105 |
| 1/2 | 105 | 110 |
| 1/4 | 110 | 115 * |
| 1/8 | 115 * | - ** |

* No exposure to continuous or intermittent noise in excess of 115 dB(A).

** Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

The OSHA regulation has an additional action level (AL) of 85 dB(A) which stipulates that an employer shall administer a continuing, effective hearing conservation program when the TWA value exceeds the AL. The program must include monitoring, employee notification, observation, an audiometric testing program, hearing protectors, training programs, and recordkeeping requirements. All of these stipulations are included in 29 CFR 1910.95, paragraphs (c) through (o).

The OSHA noise standard also states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels. Also, a continuing, effective hearing conservation program shall be implemented.

## VI. RESULTS

The dosimeter data are presented in Table 1. The information presented in the table includes the location or machine used by the worker during the survey period. The time period which the dosimeter was collecting noise data is given in the second column of the table. Eight-hour time-weighted averages (TWAs) are given in the third column. To characterize the full-shift noise exposure while operating a machine or working in a particular location, these TWAs are extrapolated to 8-hour values rather than assuming no noise exposure for the portion of the work shift not sampled. The 1-min maximum values are the highest one minute integrated value observed during the sampling period. It should be noted that this maximum value is not the highest instantaneous peak noise level, rather it is an integrated level. Finally, the table reports the percent of the sampling period where the integrated values were less than 85 dB(A), the NIOSH recommended exposure limit (REL) for noise.

The median value calculated for the noise TWAs was 84.6 dB(A). Two of the 32 noise samples were greater than 90 dB(A) TWA. However, one of these samples was for only a 3 hour period because of the employee's schedule on the day of sampling. Over one-half (17/32) of the dosimeter samples were between 83 and 87 dB(A), while only one sample was found to be less than 80 dB(A). The 1-min maximum value ranged from 86 to 104 dB(A) and had a median value of 95.5 dB(A). The median value for the percent of time spent in noise less than 85 dB(A) was calculated at 61.8%.

A total of 22 employees were asked to remove their radio headsets during the two day survey; 12 employees on the first day and 10 employees on the second day. The voltage input to the headphones was recorded at the user's volume setting, 1/3, 2/3, and full volume settings of the radio. Some of the radios seen by NIOSH investigators were not brand name products and/or did not have model numbers on the radios so that examples of these radios could not be purchased for laboratory analysis. Also, two individuals wore radio headsets that had insert type earphones that were not readily adaptable to the laboratory analysis, and were thus not purchased.

Six different radio headsets were selected from the list of radios observed and measured at the Square D Company, and were tested on KEMAR in the laboratory. The typical spectral characteristics for the types of radio programming found at the Square D Company are shown in Figures 2-6. The measured sound levels for the user's volume settings found in the workplace (Table 2) ranged from 78 dB(A) to 88 dB(A). Full volume levels exceeded 90 dB(A) for several radios.

## VII. DISCUSSION AND CONCLUSIONS

The dosimeter results reveal that employees at Square D Company spend a percentage of the work day (median value of 38.2%) at levels in excess of 85 dB(A). However, the higher noise levels are not extremely intense because the maximum exposure periods only had a median value of 95.5 dB(A) and the majority of the employees' TWAs were between 83 and 87 dB(A). It must be remembered that these noise values do not consider any additional sound exposures resulting from the use of personal radio headsets. The output from radios did not enter the microphone of the dosimeter.

The laboratory analyses of the radios showed that the levels for rock music were higher than levels for other types of programming. This difference may be attributed to how listeners set their volume controls and the spectrum of rock music. Workers using the Sony F2015, Sony SR290, Sony W2011, and General Electric GE702 earphones were exposed to potentially hazardous noise levels for both easy listening and rock music programs. Workers using the Panasonic GRF 4230 earphone were exposed to potentially hazardous noise levels for rock music. No workers listening to talk radio were exposed to hazardous levels when the players were set as sampled as the user setting. All earphones are capable of producing hazardous program levels if volume controls are rotated sufficiently for most program formats. The notable exceptions were the Sharp JC5100 and Panasonic GRF4230 earphones for talk radio programs which were both lower than the NIOSH REL when in the full volume setting.

## VIII. RECOMMENDATIONS

There is a potential for employees at the Square D Company to be exposed to noise levels exceeding the NIOSH REL of 85 dB(A) for an 8-hour TWA. The following list of recommendations are made by NIOSH investigators as a result of data obtained during the evaluation and from observations made at the Square D Company.

1. The company should continue to enforce the hearing conservation program that was in effect during the evaluation. With approximately 50% of the employee noise exposures greater than 85 dB(A), the OSHA AL requirements need to be followed. The requirements include noise monitoring, employee notification, employee observations of the noise measurements, an audiometric testing program, hearing protection devices, training programs, and recordkeeping requirements.[9]

2. Engineering controls for noise should be pursued by the Square D Company. The measured employee exposure levels were very close to the evaluation

criteria for noise, exceeding them by only a few decibels. Engineering controls, such as enclosures for noisy operations or noise barriers separating the metal stamping, pressing, and drilling operations from the assembly areas, that reduce noise by 3-5 dB(A) may be sufficient to lower employee exposures to levels that are below the OSHA regulations.

3. The personal radio headsets that were evaluated in the survey are all capable of producing hazardous noise levels if the volume controls are set at the highest level. The volume controls of an individual's radio are difficult to control and monitor to assure that sounds are always maintained at nonhazardous levels. The Square D Company should educate employees on the use of personal radio headsets in the workplace. A recent development by the Peltor Corporation has resulted in the marketing of an earmuff with a gain-limited FM radio built into the muff so that workers can have protection from noise and still listen to radio programs while working.

4. A tow motor operator was observed wearing the earphones of a personal radio while operating the tow motor. This practice should not be allowed since the driver needs his full attention for driving this vehicle in aisles where workers are present.

5. A disc grinder operator was not wearing hearing protection devices while using the grinder. The measured TWA for this employee was 93.8 dB(A), which exceeds the OSHA PEL for noise. The employees who operate grinders must wear hearing protection until this operation is quieted to a level less than the PEL.

## IX. REFERENCES

1. Skrainar SF, Royster LH, Berger EH, Pearson RG [1987]. The contribution of personal radios to the noise exposure of employees at one industrial facility. American Industrial Hygiene Association Journal, 48(4):390-395.

2. Bentler RA, Pavlovic CV [1992]. Transfer functions and correction factors used in hearing aid evaluation and research. Ear & Hearing, 13(4):284-286.

3. NIOSH [1992]. NIOSH recommendations for occupational safety and health. Compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 92-100.

4. Code of Federal Regulations [1989]. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

5. ACGIH [1992]. Threshold limit values and biological exposure indices for 1992-1993. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

6. Alberti [1591 (1970)], cited by Bunch, C.C. Traumatic deafness. In E.P. Fowler, Jr. (Editor), Medicine of the ear, chapter X. Reprinted Translations of the Beltone Institute for Hearing Research, No. 23.

7. Ward WD [1986]. Anatomy & physiology of the ear: normal and damaged hearing. Chapter 5. In: Berger EH, Ward WD, Morrill JC, Royster LH, eds. Noise & hearing conservation manual. 4th ed. Akron, OH: American Industrial Hygiene Association, pp. 177-195.

8. Ward WD, Fleer RE, Glorig A [1961]. Characteristics of hearing loss produced by gunfire and by steady noise. Journal of Auditory Research, 1:325-356.

9. Code of Federal Regulations [1989]. OSHA. 29 CFR 1910.95. Washington, DC: U.S. Government Printing Office, Federal Register.

10. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to noise. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 73-11001.

11. ACGIH [1990]. 1990-1991 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.

## X. AUTHORSHIP AND ACKNOWLEDGEMENTS


| | |
|---|---|
| Report Prepared by: | Randy L. Tubbs, Ph. D.<br>Psychoacoustician<br>Industrial Hygiene Section<br><br>John R. Franks, Ph.D.<br>Physical Scientist<br>Bioacoustics and Occupational Vibration Section<br>Physical Agents Effects Branch<br>Division of Biomedical and Behavioral Science |
| Laboratory Analysis: | Curtis W. Sizemore<br>Krinna Patel<br>Bioacoustics and Occupational Vibration Section<br>Physical Agents Effects Branch<br>Division of Biomedical and Behavioral Science |
| Originating Office: | Hazard Evaluations and Technical Assistance Branch<br>Division of Surveillance, Hazard Evaluations, and Field Studies |
| Report Typed By: | Kate L. Marlow<br>Office Automation Assistant |


## XI. DISTRIBUTION AND AVAILABILITY OF REPORT

 Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Loss Control Supervisor, Square D Co.

2. Union Safety Representative, IBEW Local 2287

3. U.S. Department of Labor/OSHA, Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

Noise Dosimeter Results

HETA 90-281
Square D Co. - Oxford, Ohio
April 23-24, 1991 and May 20, 1991

| Location | Sample Period [H:MM:SS] | 8-Hr TWA [dB(A)] | 1-Min. Maximum Level [dB(A)] | % Time < 85 dB(A) |
|---|---|---|---|---|
| Shears | | | | |
| CSM101 | 7:47:58 | 84.2 | 94 | 51.4 |
| SO1201 | 7:02:22 | 87.4 | 100 | 37.7 |
| Presses | | | | |
| P11001 | 3:05:35 | 91.0 | 103 | 44.3 |
| TURRET 103 | 7:36:31 | 83.3 | 96 | 73.2 |
| PT106 | 7:41:20 | 83.3 | 95 | 70.5 |
| PO6020 | 7:35:50 | 88.0 | 99 | 36.3 |
| NATCO T103 | 7:36:01 | 85.3 | 92 | 42.3 |
| AMADA PT114 | 7:21:43 | 84.7 | 100 | 61.9 |
| 3P15002 | 6:58:19 | 85.6 | 96 | 32.5 |
| AMADA PT 110 | 7:05:55 | 87.0 | 100 | 35.3 |
| Assembly Groups | | | | |
| 602 - Welder | 7:06:59 | 82.2 | 102 | 85.7 |
| 603 - Welder/Grinder | 6:46:29 | 86.2 | 101 | 61.8 |
| 626 - Assembler | 7:47:06 | 85.2 | 95 | 48.8 |
| 626 - Assembler | 7:46:41 | 79.4 | 86 | 99.1 |
| 626 - Assembler | 6:58:52 | 87.2 | 99 | 50.2 |

Table 1 (Continued)

Noise Dosimeter Results

HETA 90-281
Square D Co. - Oxford, Ohio
April 23-24, 1991 and May 20, 1991

| Location | Sample Period [H:MM:SS] | 8-Hr TWA [dB(A)] | 1-Min. Maximum Level [dB(A)] | % Time < 85 dB(A) |
|---|---|---|---|---|
| Assembly Groups | | | | |
| 632 - Bar Wrap | 7:33:21 | 82.8 | 90 | 73.5 |
| 632 - Grinder | 7:12:52 | 93.8 | 102 | 22.9 |
| 632 - Assembler | 7:01:15 | 85.0 | 98 | 63.6 |
| 644 - Assembler | 7:33:45 | 85.5 | 97 | 45.2 |
| 644 - Assembler | 7:30:48 | 80.2 | 95 | 88.4 |
| 661 - Hanger | 7:03:32 | 84.6 | 91 | 51.8 |
| 661 - Assembler | 6:46:35 | 86.6 | 97 | 41.4 |
| 663 - Assembler | 6:33:47 | 83.7 | 94 | 70.5 |
| 663 - Assembler | 7:39:08 | 85.2 | 93 | 46.2 |
| 692 - Riveter | 7:21:18 | 83.7 | 94 | 69.2 |
| 694 - Assembler | 7:07:27 | 80.1 | 91 | 90.6 |
| 695 - Assembler | 7:06:59 | 81.8 | 92 | 81.7 |
| 696 - Assembler | 3:31:01 | 81.1 | 90 | 90.0 |
| Other Jobs | | | | |
| Spray Painter | 6:33:38 | 87.1 | 104 | 31.6 |
| Tow Motor Oper. | 6:57:16 | 83.4 | 95 | 61.9 |
| Maintenance | 7:05:17 | 81.8 | 96 | 81.2 |
| Wood Crater | 7:08:32 | 81.8 | 91 | 75.7 |

Table 2

Sound-Field Equivalent Output of Radio Earphones [in dB(A)]

HETA 90-281
Square D Co. - Oxford, Ohio
April 23-24, 1991

| Earphone Type and Station | Volume Control Settings | | | |
|---|---|---|---|---|
| | User Setting | 1/3 | 2/3 | Full |
| Sony - F2015 | | | | |
| * Easy Listen | 85.5 | 65.1 | 83.6 | 92.3 |
| * Rock | 87.2 | 79.2 | 88.4 | 93.6 |
| * Talk | 82.0 | 63.9 | 76.5 | 86.9 |
| Sony - SR290 | | | | |
| * Easy Listen | 86.0 | 65.6 | 84.1 | 92.8 |
| * Rock | 88.1 | 80.1 | 89.3 | 94.5 |
| * Talk | 82.4 | 64.3 | 76.9 | 86.3 |
| Sony - W2011 | | | | |
| * Easy Listen | 84.4 | 64.0 | 82.5 | 91.1 |
| * Rock | 86.1 | 78.1 | 87.4 | 92.6 |
| * Talk | 80.9 | 72.8 | 75.4 | 84.8 |

Table 2 (Continued)

Sound-Field Equivalent Output of Radio Earphones [in dB(A)]

HETA 90-281
Square D Co. - Oxford, Ohio
April 23-24, 1991

| Earphone Type and Station | Volume Control Settings | | | |
|---|---|---|---|---|
| | User Setting | 1/3 | 2/3 | Full |
| Sharp - JC5100 | | | | |
| * Easy Listen | 81.5 | 61.1 | 79.6 | 88.2 |
| * Rock | 83.9 | 75.9 | 85.1 | 90.3 |
| * Talk | 77.7 | 59.6 | 72.2 | 81.6 |
| Panasonic - GRF4230 | | | | |
| * Easy Listen | 82.8 | 62.4 | 80.9 | 89.6 |
| * Rock | 84.4 | 76.4 | 85.7 | 90.9 |
| * Talk | 79.4 | 61.2 | 73.8 | 83.2 |
| General Electric - GE702 | | | | |
| * Easy Listen | 84.7 | 64.2 | 82.8 | 91.4 |
| * Rock | 86.1 | 78.1 | 87.3 | 92.5 |
| * Talk | 80.9 | 62.8 | 75.4 | 84.8 |

**Figure 1**

**Schematic Diagram of Field Equipment**

**HETA 90-281**
**Square D Company**
**Oxford, Ohio**

**April 23-24, 1991**

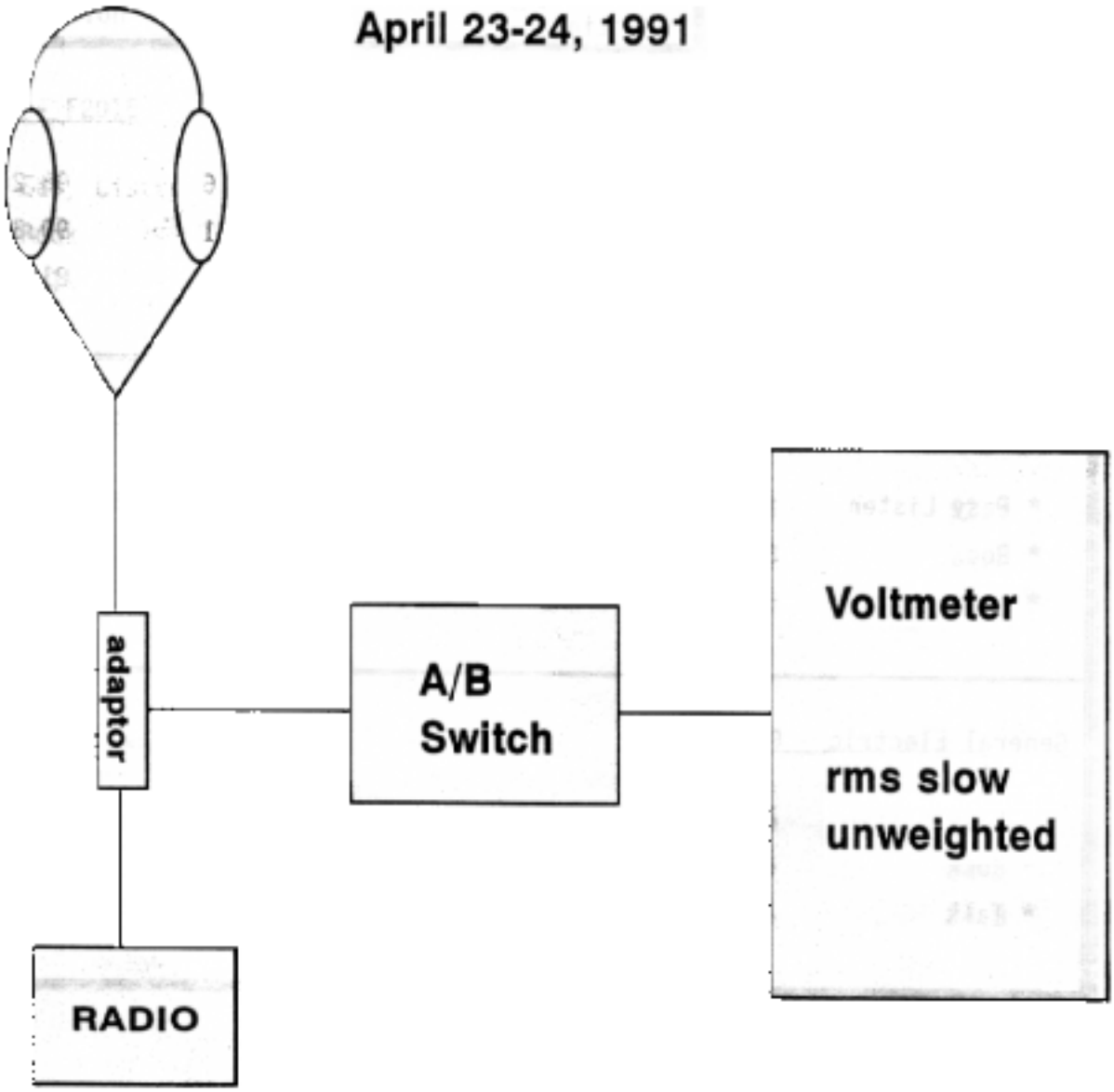

Figure 2

## Easy Listening Music
## Typical Spectrum

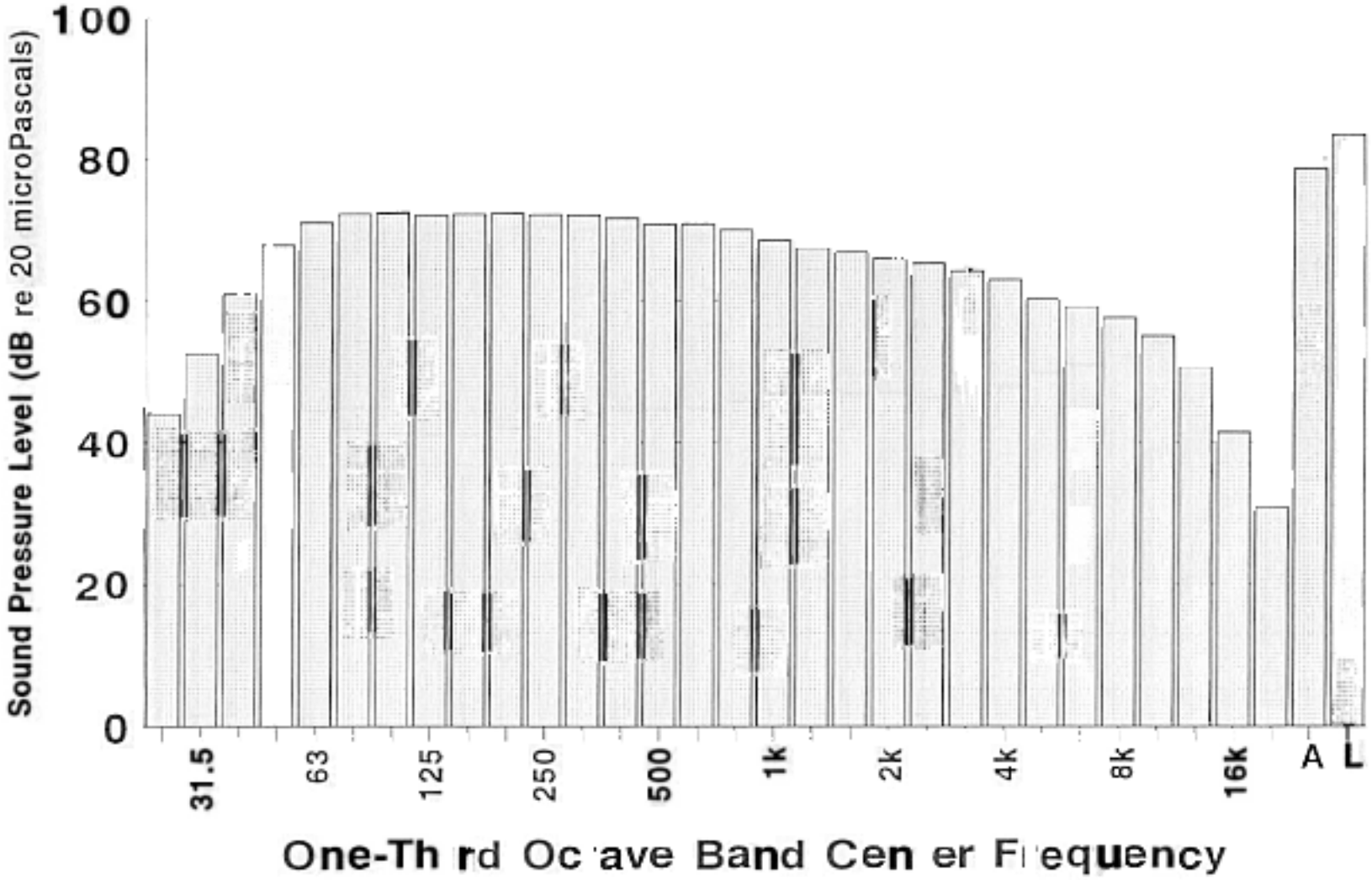

Figure 3

## Rock Music
## Typical Spectrum

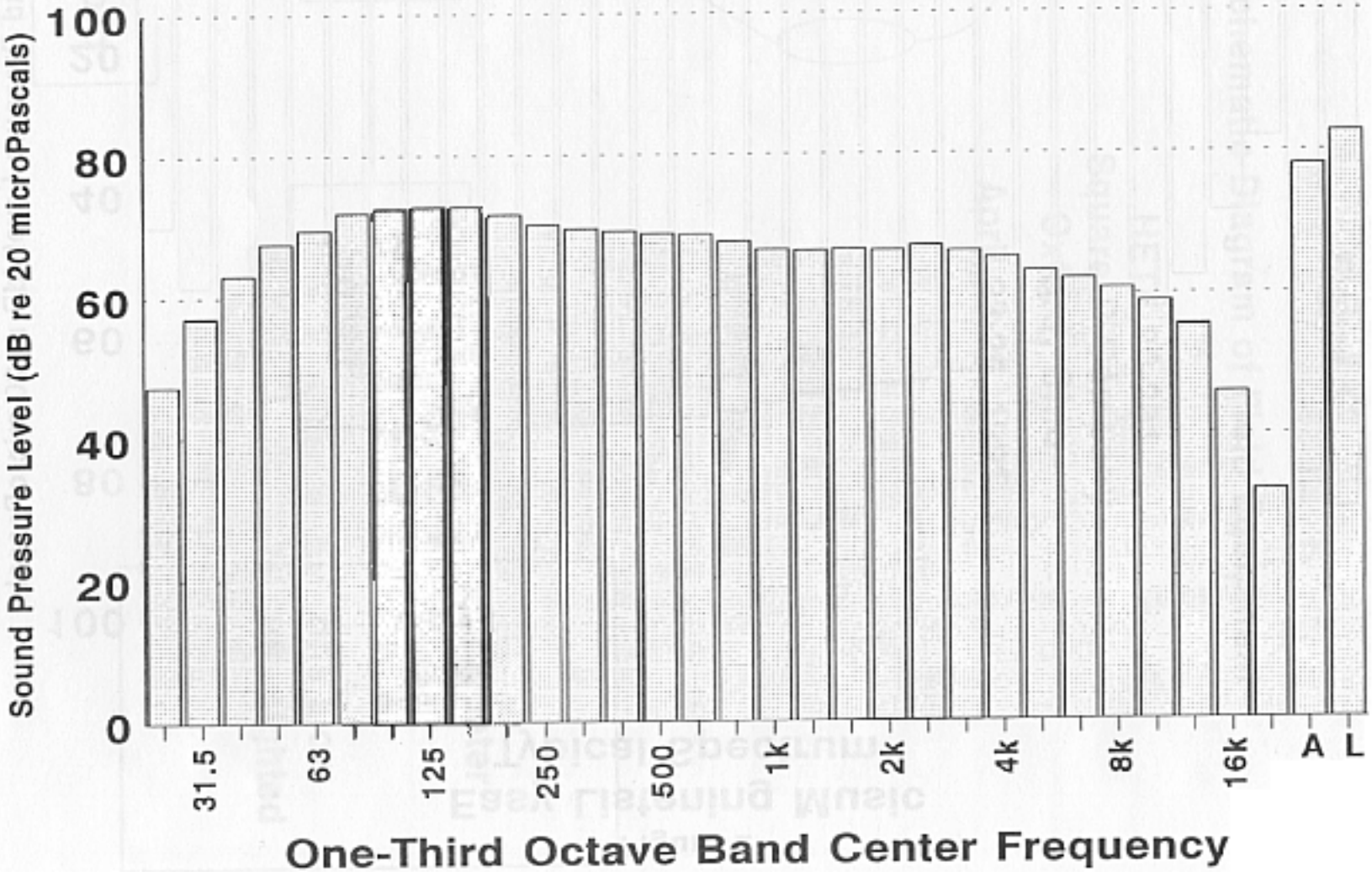

Figure 4

## Country Music
## Typical Spectrum

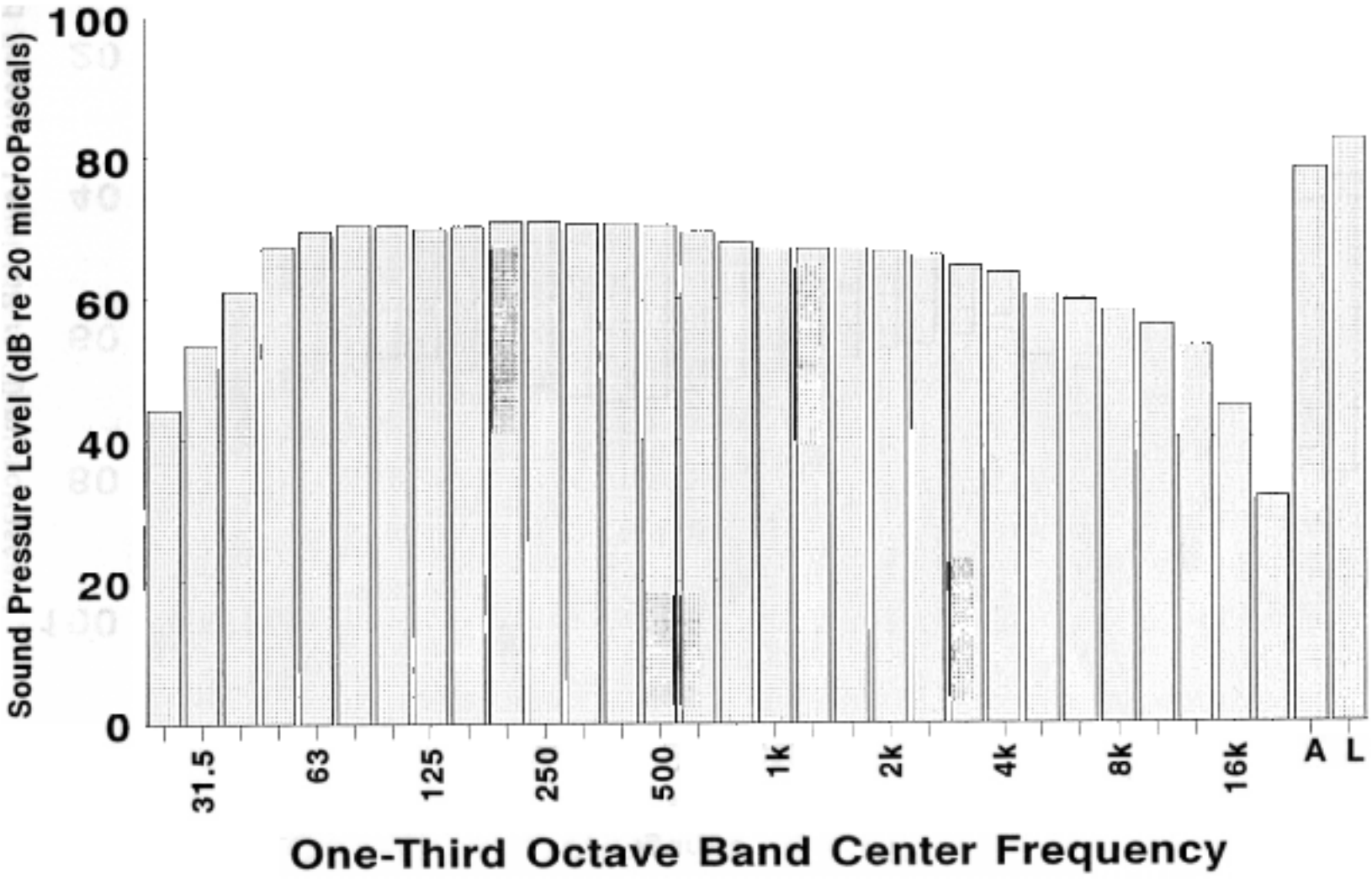

Figure 5

## Talk Radio
## Typical Spectrum

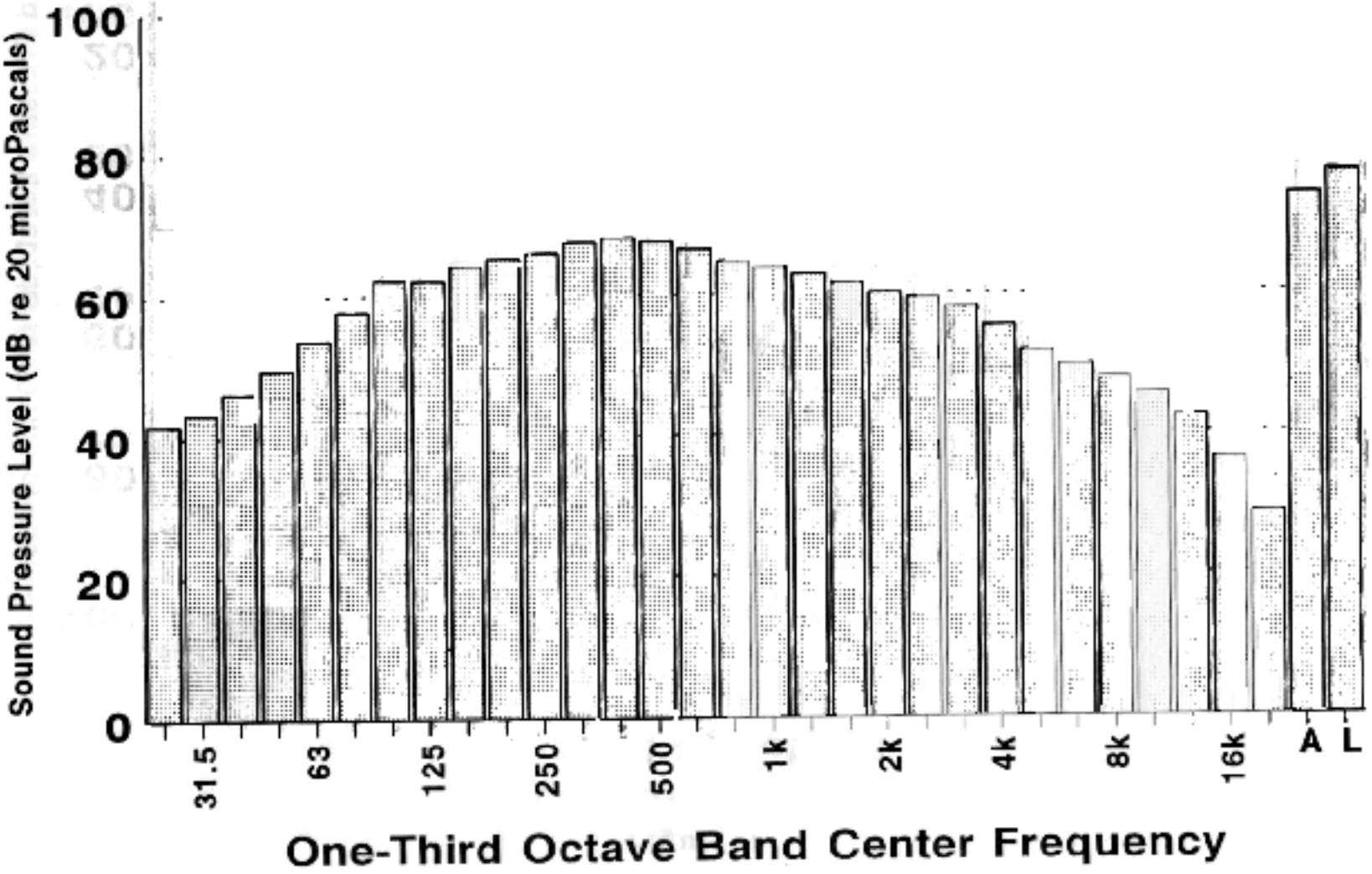

Figure 6

**Classical Music**
**Typical Spectrum**