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Rationale and Recommendations For changes and Revisions to the HUD Noise Measurement Systems Specifications

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ABSTRACT

In 1973, the Office of Noise Abatement Research, Department of Housing and Urban Development, contracted with the Applied Acoustics Section of the National Bureau of Standards to develop a noise exposure measurement system. This system was subsequently developed, seventeen prototype units were procured, and a full-scale laboratory and field evaluation of the units were conducted. This report discusses the results of the evaluation, as well as the rationale behind and recommendations for changes and revisions to the HUD noise measurement system specifications.

Key Words: Acoustics; community noise; environmental impact; noise; noise exposure measurement system; sound.

1. INTRODUCTION

In 1973, the Office of Noise Abatement Research, Department of Housing and Urban Development, contracted with the Applied Acoustics Section of the National Bureau of Standards to develop a noise exposure measurement system (NEMS). This system would provide an inexpensive, reliable means for accurate, quantitative assessment of the noise environment at prospective building sites or other areas of concern regarding noise. It would be specifically tailored to measure conformance to the interim external noise exposure standards of HUD Departmental Circular 1390.2.[1][1/] Thus, NBS designed a self-contained system which consisted of two main components. There was a Monitor which collected the following data over a 24-hour period:

1. The accumulated time that 80 dB(A) was exceeded.

2. The accumulated time that 75 dB(A) was exceeded.

3. The accumulated time that 65 dB(A) was exceeded.

4. The accumulated time that 45 dB(A) was exceeded.

5. The number of times 80 dB(A) was exceeded.

6. The accumulated time the wind was greater than 20 knots.

[1/] The numbers in brackets indicate the literature references at the end of this report.

The other component of the system was a Reader, which read out the above data, as well as the Monitor identification number, to the field investigator when the test was completed. Once the design was completed, NBS built two prototype systems and field tested them to ensure that they operated properly. When it was assured that the NBS-built systems were operating as desired, a set of system specifications were drawn, and a bidding procedure commenced to award a contract to a commercial firm to build seventeen NEM systems to be used for field testing by HUD personnel. The contract was subsequently awarded and the systems built, and a full field test and evaluation of each system was conducted.

The tests of each commercially-built NEMS were carried out in four steps: (1) an incoming acceptance test; (2) a dummy model test; (3) validation of the system; and (4) field testing of the system by HUD personnel. This report will discuss each of these tests as well as present the results of the tests which led to the changes and revisions to the HUD noise measurement system specifications which are recommended at the conclusion of this report. A copy of the revised performance specification in which the changes recommended in this report are incorporated is given in Appendix A.

2. ACCEPTANCE TESTS OF THE HUD NOISE MEASUREMENT SYSTEM

2.1. Incoming Acceptance Test

Each of the seventeen measurement systems was tested by NBS upon receipt from the contractor. The acceptance tests consisted of the following: (1) the A-weighting was checked to determine frequency response; (2) the detectors were tested to determine crest factor capability; (3) the operation of the comparators were tested to determine that the quantitazation levels were as specified in Circular 1390.2; (4) the signal-to-noise ratio was determined; (5) the operation of the memory registers was determined; and (6) the accuracy of the windspeed indicator was determined. As a result of these tests, three units were rejected -- two because of memory and/or clock failure and one because the A-weighting did not meet specifications.

The above tests were then performed in an environmental chamber in a temperature range of -20 to 80°C at 100% relative humidity, and it was found that the system drifted more than the specifications allowed. This was due to the fact that the piezoelectric microphone, which had been utilized in the NBS design and incorporated into the contractor's system, had a temperature coefficient that was much greater than specifications. This was caused by a materials problem in the manufacture of the microphone cartridges and was solved by changing to a conventional (air) condenser microphone. However, in order to make the new microphone compatible with the system, extensive redesign was necessitated. The input amplifier had to be redesigned so that it could be interfaced with the high impedance condenser microphone. Additionally, gains had to be changed due to the characteristic differences between the piezoelectric and condenser microphones. Finally, the input amplifier had to be further redesigned because of instability caused by the microphone preamplifier.

After the system was redesigned, the tests were then rerun in the environmental chamber under the temperature and humidity conditions, and the measurement system conformed to specifications.

2.2. Dummy Model Test

The main purpose of this test was to determine the susceptability of the system to vandalism and theft. Four cases having the same size and configuration as the actual noise measurement system were constructed of wood. These cases were then placed in the same polyurethane covers as are used in the measurement system, and the same windscreens and goosenecks as are used in the system were attached to the covers. A wind sensor, constructed of wood, but painted the same color as an actual one, was also attached. Three of these dummy systems were mounted on utility standards at different locations in Washington, D. C. for a period of one week. The fourth dummy unit was mounted near Interstate 270 in Rockville, Maryland. The mounting heights varied from 2 to 4 meters. In all cases, the dummy systems were not vandalized.

2.3. Preliminary Field Tests

Although the measurement system was tested for environmental effects during development and accuracy and drift were measured, it was considered desirable to conduct parallel measurements with more conventional measurement techniques to demonstrate both the simplicity and versatility of the system and also its accuracy and precision. Thus, the HUD measurement system and two other systems, were used to measure noise in the following environments: (1) a suburban area subject to light traffic and (2) near an Interstate highway subject to heavy traffic.

The first series of measurements were made at site 1, which was on the NBS grounds along Quince Orchard Road. Data were collected using three systems: (1) the HUD noise measurement system; (2) a level recorder and statistical distribution analyzer; and (3) a computer with an analog-to-digital converter and digital magnetic tape. The computer system included an asynchronous external memory so that data were written on magnetic tape without losing new input data and a time of day clock for synchronizing data between the HUD system, the level recorder system, and the computer. The digital magnetic tapes were read on the NBS Univac 1108[2/] computer and the data were binned in 5 dB increments.[3/] A complete list of equipment for systems 2 and 3 is given in Tables 1 and 2.

[2/] Certain commercial equipment, instruments, and materials are identified in this report in order to adequately specify the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

[3/] A more complete discussion of the computer system is given in Ref. 2.

Table 1. List of equipment used in level recorder system.

Manufacturer	Instrument	Model No.
B & K Instruments	Outdoor Microphone	4921
B & K Instruments	Amplifier	2606
B & K Instruments	Graphic Level Recorder	2305
B & K Instruments	Statistical Distribution Analyzer	4420

Table 2. List of equipment used in computer system.

Manufacturer	Instrument	Model No.
B & K Instruments	Outdoor Microphone	4921
B & K Instruments	RMS/Log Converter	215
National Bureau of Standards	Interface/ADC	--
Raytheon	Computer System	704

For the level recorder and computer systems a B & K type 4921 outdoor microphone system was used. This system has a 1 kHz electrostatic actuator for calibration and was remotely calibrated under computer control every 52 minutes. This system has the advantage that it can be used under any weather conditions. The first validation test was conducted on July 25, 1974 for a period of 24 hours, and the results are given in Table 3.

As can be seen from the table, there was reasonable agreement between the results obtained using the HUD and computer systems. Both systems could be in specification and still not be in exact agreement because of allowances in A-weighting network and gate trip points. However, the differences between these two systems and the level recorder system are much greater than would be expected. Possible reasons for these differences are: (1) the level recorder has a servo system which has equivalent meter ballistics which are not present in the HUD or computer systems; (2) the writing speeds possible on the level recorder do not correspond exactly to "fast" or "slow" as specified in American National Standard S1.4-1971[3] and (3) the level recorder is really recording the mean detected value as opposed to the root-mean-square value which the HUD and computer systems record.

Data for site 2, which was approximately 30.5 meters from the center of the near lane on Interstate 270, were taken for a 24-hour period beginning August 10, 1974, using the HUD system and the computer system. The results are given in Table 4. It should be noted that no level recorder system data were obtained at this site. It was decided not to use the level recorder system for this phase of the tests, as it did not conform to American National Standard S1.4[3] as the other systems did. The results of the test show that the HUD system agrees very well with the computer system. The differences, which are the greatest in the 45 to 65 and 65 to 75 intervals, appear to be due either to differences in the gate trip points or the tolerance in the A-weighting network of the two systems.

2.4. Field Testing of the HUD Noise Measurement System

2.4.1. Rationale for Field Testing Phase

The tests discussed in previous sections of this report showed that the HUD noise measurement system would probably not be subject to vandalism and that the data recorded by the system were accurate. The field phase of the testing program was designed to provide information as to how well a person unskilled in acoustical measurements and instrumentation -- the user -- could carry out the instructions and operations necessary to utilize the system. (The HUD Noise Measurement System Operation Instructions and the Field Use Instructions for the HUD Noise Measurement System are given in Appendices B and C, respectively.) Basically, when the measurement system is used, the operator must perform seven major steps: (1) determine the location where the greatest noise exposure most probably exists; (2) calibrate the Monitor; (3) mount the Monitor at the location found in step 1 and activate it; (4) remove the Monitor from the mounting; (5) recalibrate the Monitor and read the data; (6) interpret the results of the

Table 3. Results of the validation test conducted on July 25-26, 1974, on NBS grounds along Quince Orchard Road (Site 1).

A-weighted Sound Level Interval (dB)	Time Interval (hr.)		
	HUD System	Computer System	Level Recorder System
Less than 45	2.74	3.97	.106
45-65	18.66	17.65	22.74
65-75	2.48	2.05	1.23
75-80	.07	.053	.028
80-85	.00	.006	.002

Table 4. Results of the validation test conducted on August 10-11, 1974, approximately 30.5 meters from Interstate 270 (Site 2).

A-weighted Sound Level Interval (dB)	Time Interval (hr.)			
	HUD System Number			Computer System
	4087	4089	4090	
Less than 45	.23	.65	.36	.00
45-65	19.94	21.02	20.67	21.46
65-75	3.61	2.02	2.79	2.42
75-80	.19	.65	.16	.09
Greater than 80	.00	.00	.02	.00

measurements; and (7) decide whether or not additional measurements are necessary from steps 1 and 4.

The first step in the deployment of the measurement system is to determine the most appropriate location(s) for the Monitor. The NBS instructions for locating the Monitor on a site utilize information, in the form of written instructions, nomographs, and tables, given in the present Noise Assessment Guidelines[4]. One of the purposes of the field testing was to determine the suitability of the NBS instructions by examination of (1) user acceptance, (2) ease of use, (3) expert judgment, (4) the time required to use the instructions, and (5) consistency.

The next steps in the use of the system are calibration and mounting. The fundamental problem in calibration is following instructions, and the appropriateness of the instructions were judged by the amount of time it took to complete the task and the number of errors which occurred in performing the task. Other items which were evaluated were (1) the intensity and discriminability of the light-emitting-diode (LED) indicators and (2) the ease with which the system gain could be adjusted by the operator. Finally, any problems with the automatic shut-off of the calibrator were determined; e.g., should the "on" time be changed, and were the instructions for the battery check adequate.

After the system is calibrated, it must be mounted on the field mounting pole or a utility standard. The testing program evaluated the entire mounting procedure with particular attention to the problems of mounting at a lower height than specified, dropping the system, and the difficulty of using the Monitor strapping.

After the 24-hour measurement period, the operator must remove the Monitor, perform the second calibration, and read out the data. Again, the potential for dropping the system is present if the operator does not use the shock cord or if the strapping is difficult to cut. The operator must again follow instructions for the second calibration as well as for connecting the Monitor to the Reader. The appropriateness of the instructions were determined by analysis of the number of errors made and by the amount of time it took to perform the operations. In addition, the effect of sunlight on the visibility of the LED readout in the Manual Reader was determined. Finally, in using the measurement system during this phase of the procedure, the most probable items to be damaged were the wind sensor and microphone. Damage to the microphone was indicated by the operator's inability to calibrate the system. Damage to the wind sensor was determined by a visual examination using a set of instructions. The adequacy of the instructions was determined by the field testing.

Finally, after the measurements are made, the results must be interpreted. Through examination of the results, the operator must decide whether any further measurements need to be made, and if the results obtained with the system seem to be reasonable. This can be assessed by comparing the measured results with those predicted from the NBS instructions. The field testing was to establish the allowable difference between the predicted and actual results.

2.4.2. Field Testing Program

A HUD noise measurement system was delivered to each of the ten HUD regional offices[4/] during the months of May and June 1975. During July and August 1975, one additional NEMS was delivered to the New York, Chicago, and San Francisco offices. During the initial delivery of the NEMS, a representative from NBS trained HUD field personnel in the use of the system. The usage was closely monitored by NBS personnel during the first six months through written use logs (a three-page questionnaire which was filled in by the user each time a site was measured) and telephone calls. Much of the data reported in Section 2.4.3 of this report is taken directly from the use logs[5/], and a copy of the use log is reproduced in Appendix D.

In regard to finding a location on which to mount the Monitor, instructions were given to several of the HUD regional office personnel at the time of initial delivery of the system. They were to use these instructions to determine the appropriate location(s) of the Monitor at a typical site. In parallel with the HUD representative, a person from NBS also independently determined the the appropriate location. Ideally, of course, both would derive the same location. The appropriateness of the location was then judged by the NBS project leader. In addition, HUD personnel using the instructions were interviewed regarding difficulties encountered while interpreting the instructions, and were asked to suggest improvements in wording, format, organization, etc.

Following the initial deliveries of the HUD system to the regional offices, the HUD personnel were left on their own to conduct the field testing and return the use logs to NBS. The results of this field testing and the NBS recommendations for changes to the HUD system which resulted from the field testing are given in subsequent sections of this report.

[4/] The HUD regional offices are located in the following cities: Boston, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Atlanta, Georgia, Chicago, Illinois; Dallas, Texas; Kansas City, Kansas; Denver, Colorado; San Francisco, California; and Seattle, Washington.

[5/] In all, 106 Use Logs were returned from the Regional Offices. However, for a number of reasons (which will be discussed in the course of the report), 20 of the logs reported no data from the Monitor.

2.4.3. Results of the Field Testing

Determination of the location where the greatest noise exposure exists: From the information given in the Use Logs, virtually no difficulty was encountered in finding a location for the Monitor. Only four Use Logs reported having had difficulty, and the problem seemed to be caused not by being able to determine the location, but by being unable to find a tree, utility standard, or post on which to mount the Monitor. The time taken to find the location ranged from one minute to one hour, with about half the users reporting it took five to ten minutes. Eighty-three percent of the users determined the location in ten minutes or less, and 99 percent in 30 minutes or less. In tests where NBS personnel determined the Monitor location simultaneously with HUD personnel, the locations chosen were very similar. This verified that the instructions for this phase of the test were sufficiently clear and detailed.

Calibration of the System: The initial calibration of the HUD measurement system appeared to cause the user little problem. Only four of the Use Logs specifically reported problems calibrating the system. From these four, the following problems were cited: the calibration enable light went back and forth between red and green; the calibrator "on" time would not hold for the full 45 seconds,; the battery check light did not come on; the battery check light flashed; the Monitor would not calibrate in hot temperatures; the Monitor would not calibrate with the wind sensor on; the operation is too difficult to be done in the field; and the calibrator itself was malfunctioning. In addition, two of these Use Logs reported the time it took to perform the calibration -- one reported a time of 30 minutes. During this phase of the program, no one reported having difficulty in adjusting the system gain.

Finally, there was a question in the Use Log designed to indicate the intensity and discriminability of the LED indicators. Forty-eight of the users indicated that they had no trouble reading the indicators. Twenty-nine said that they could read them, but with difficulty, and six of the users said that they were very difficult to read in bright sunlight. As this question was only asked of persons who performed the calibration at the measurement site, the above responses do not sum to 105 because seven users did not answer the question and the rest calibrated the system in their office or car.

Mounting the Monitor: The mounting of the Monitor appears to be the first phase of the testing which caused any substantial problem. Seventy-two users reported that they experienced no difficulty, twenty-eight indicated that they did have difficulty, and five users provided no information. Of those who experienced difficulty, the main complaints seemed to be that the shock cord was too short and that the banding of the system was difficult to accomplish. Each of these complaints was reported eleven times. Other problems that occurred in mounting the system were that the shock cord fasteners could not be secured well, the wind sensor was difficult to mount, bending the buckle ears was difficult, the cutting tool was difficult to use, and lack of experience. The time taken to mount the

Monitor ranged from one minute to 60 minutes, with 50 percent of the users reporting that it took 10-15 minutes. Seventy-eight percent mounted the Monitor in 15 minutes or less, and 94 percent in 30 minutes or less.

The mounting height had to be sufficiently high enough to discourage and/or prevent vandalism and theft. A minimum height range of eight to twelve feet was recommended. From the Use Logs, it was determined that 63% of the users mounted the Monitor within this range, and an additional 25% mounted the system at heights ranging from 13 feet to 65 feet. Fifteen users, or fourteen percent, mounted the system lower than the recommended height.

Dismounting the Monitor and performing the second calibration: Removing the Monitor from its mounted position caused virtually no problems serious enough to be noted in the Use Logs. Only one user noted having a problem, and this was caused by being unable to get the cutters underneath the strap to free the Monitor from the mounting pole. The user solved his own problem in subsequent tests by inserting a block of wood between the strap and the pole, thereby leaving a space large enough to insert the cutters.

The second calibration of the HUD system caused substantially more problems than the first. Seventeen Use Logs reported failing to perform the second calibration. Four Use Logs did not specify whether they were successful or not, three did not complete the test runs due to excessive wind, and 82 successfully performed the second calibration. Of the 17 unsuccessful attempts, only four noted in the logs what they believed the problem to be. One user thought that the calibrator was at fault and three noted that they were unable to perform the calibration with the wind sensor attached to the system.

Readout of the data: As noted earlier, 20 (19%) of the Use Logs returned to NBS (out of 106 total) reported no data. Of these, six Logs gave no reason as to why no data were collected. From the other logs, a variety of reasons were given. One person voided his data because they exceeded 24.05 hrs. In another case, the system was vandalized. Two Use Logs noted that the wind speed exceeded the capacity of the system. This latter instance happened to the same user two times in a row, and in order to ascertain whether the system was malfunctioning, he ran a test in his office. The system was functioning properly but no data were reported for this run. In two cases, the tape on the automatic reader jammed, and the data were printed out superimposed and thus illegible. In seven cases, data were not obtained because the user was unable to calibrate the system. In one case, the user could not calibrate and did not attempt to read the data. In the other instances, the users, after trying and failing to calibrate, attempted to read the data, but all that was printed out by the Reader was "UC".

Interpreting the data: The data from these tests are to be interpreted as specified in HUD Departmental Policy Circular 1390.2[1]. As the data were interpreted by HUD personnel, two of the sites tested were judged to be unacceptable, thirteen were judged to be discretionary-normally unacceptable, sixty-five were judged to be discretionary-normally acceptable, and two were judged to be acceptable. With only 18.5% of the sites falling into the unacceptable categories, one might question the necessity of using such a system to characterize the sites. However, when the data were returned to NBS, they were re-evaluated to see how many sites might be marginal in terms of their category of acceptability. In other words, for a site to be considered discretionary-normally acceptable, its noise climate must not exceed 65 dB(A) more than 8 hours/24 hours. How many sites were there in which 65 dB(A) was exceeded for 6-8 hours/24 hours, and thus almost placing them in the discretionary-normally unacceptable category (exceeds 65 dB(A) 8 hrs./24 hrs)? In addition, how many sites were judged discretionary-normally unacceptable (does not exceed 75 dB(A) more than 8 hrs/24 hrs.) but where 75 dB(A) was exceeded 6-8 hrs/24 hrs., thus almost qualifying it for the unacceptable category? When the data were examined in this manner, almost a third of the sites would be in these marginal categories: 75 dB(A) was exceeded 6-8 hrs/24 hrs. at one site and 65 dB(A) was exceeded 6-8 hrs/24 hrs. at 26 sites. These 27 cases plus the fifteen which were clearly classified in unacceptable categories comprise almost 51% of the sites for which data are reported. This clearly indicates a need for a device which will provide an inexpensive, accurate assessment of the noise to which potential HUD construction sites are subjected.

<u>Other problems encountered by HUD field test personnel</u>:

a) System failures: A log was kept by NBS of failures to the HUD Noise Measurement System. As of February 5, 1976, thirteen failures had been reported by the HUD regional field offices. The reasons for these failures are given in Table 5.

b) Wind sensor: Three problems arose with the use of the wind sensor. Two of the Use Logs noted that it was difficult to connect the wind sensor to the Monitor. Although this does not appear to be significant, there were many verbal complaints by HUD personnel to NBS about this problem. Three of the Logs mentioned that it was impossible to mount the Monitor with the wind sensor attached. In all three cases, the user operated the system without attaching the wind sensor. Finally, although it does not appear in any of the Logs, it was reported verbally to NBS that there were several instances where the wind sensor shorted out due to moisture getting into it, thereby causing the data which had been collected to be voided.

c) Automatic Reader: The Use Logs mentioned two problems that occurred with the Automatic Reader. In three instances, it was reported that the printout on the paper tape was faulty. The numbers were printed by an arrangement of dots and in all of these cases some of the dots were not being printed. For example, a zero was normally printed in the following way .

Table 5. Reasons and number of occurrences for failures of the HUD Noise Measurement System.

Reason	No. of Occurrences
Preamplifier damaged by moisture	2
Microphone damaged by removing calibrator too rapidly	4
Bad batteries in Reader	1
Bad calibrator	1
Windsensor damaged in transit	1
Windsensor damaged by mishandling	2
Automatic Reader damaged in transit	2
	TOTAL 13

During the malfunction, zero appeared as , which bears more resemblance to a nine than a zero. Obviously, this caused confusion in reading the data, and in one case, necessitated a duplicate run to verify the results.

The other problem, which was reported twice in the Use Logs and a number of times by telephone, was that the paper tape jammed in the Automatic Reader, thereby causing all the characters to be printed at one position and making the data unreadable. From discussions with users, it appeared that this was caused by failure to secure the connector used for interconnecting the Reader and the Monitor in its holder in the Reader lid. When the connector was not held in place, it knocked the tape cover of the paper holder loose, causing the paper to become unthreaded. If the paper was not rethreaded correctly, it would bind, causing the characters to be printed superimposed.

In spite of the aforementioned problems, many users verbally expressed a strong preference for the Automatic Reader as opposed to the Manual Reader.

d) Carrying case for the HUD System: One Use Log made the comment that the latch on the HUD System carrying case had broken. In fact, three original carrying cases (which were ordinary suitcases) used for the system were ruined because they were not sturdy enough to withstand the rigors of field testing. Two aluminum cases were purchased to try out as a possible replacement for the original cases. They were taken into the field in the New York and San Francisco HUD regional offices, and they have remained in excellent condition throughout the testing program.

e) Moisture problems: It was reported several times by telephone and once in the Use Logs that condensation and/or water was getting inside the Monitor case. Since this had the potential of shorting out the Monitor, it was decided to pack a dessicator in the lid of the Monitors. Although one user has subsequently complained that the dessicator made the case door difficult to shut, there have been no moisture problems reported since the dessicator was placed in the case.

f) Several persons reported that they lost their data because they inadvertently turned off the main power switch of the Monitor while they were dismounting it.

g) There were a number of complaints, both verbal and written, about the difficulty of connecting the windsensor to the Monitor. It was not possible for the user to see the connection point while performing the operation, and he had to depend on a sense of feel. Also, the manner in which the connection had to be made was causing the connection point to wear out rapidly.

3. RECOMMENDATIONS FOR CHANGES AND REVISIONS TO THE HUD NOISE MEASUREMENT SYSTEM SPECIFICATIONS

As a result of the field testing, thirteen changes to the HUD System specifications are recommended. Each change will be discussed briefly below.

1. Carrying Case: As was discussed earlier, the original carrying cases did not successfully withstand use in the field. Two aluminum cases which were purchased as experimental replacements have performed with no failures. Therefore, it is recommended that the carrying case used for the HUD System be of the aluminum type or a type which will perform equally as well as the aluminum case.

2. Clip to hold paper in place in Automatic Reader: To prevent the paper tape from becoming unthreaded in the Automatic Reader, it is recommended that a clip be added to hold the paper in place. This eliminates the possibility that the paper will become unthreaded, be rethreaded improperly, subsequently bind, and print out the characters superimposed.

3. Automatic Reader: It is recommended that the Manual Reader be dispensed with, and that only the Automatic Reader be used with the HUD System.

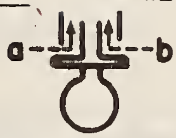
4. Print head: Based on cost considerations, a new print head for the Automatic Reader will be utilized. Use of this new print head will reduce the cost of this particular item in the system by a factor of four.

5. Microphone: It is recommended that the one-half-inch condenser microphone currently specified be replaced with an air condenser or electret microphone which is less expensive and more rugged. It was found that the one-half-inch microphone is too fragile for use in field testing by acoustically inexperienced personnel.

6. Dessicator for Monitor lid: To eliminate moisture problems which occurred in the field, it is recommended that a dessicator be packed into the lid of the Monitor.

7. Separate container for banding material: The banding material for the HUD System is made of stainless steel and is quite bulky and heavy. Many users complained that it made the carrying case quite heavy to carry, and, in addition, they were afraid it would damage the more sensitive acoustical equipment. Thus, it is recommended that a separate case be used to carry the banding material.

8. Rainshroud for wind sensor: The wind sensor had originally been designed as follows:



Rain was entering the sensor at points a and b. This shorted out the sensor, causing it to indicate that the performance of the sensor had been exceeded for the whole period the Monitor was in operation. Thus, the data had to be voided and the test repeated. To prevent water from getting into the sensor, it is recommended that a rainshroud be added to the wind sensor, as in the following diagram.

9. Shock cord: Due to the problems encountered by the persons who conducted the field testing, it is recommended that the 18-inch shock cord be replaced with a longer cord which would be sufficient to encircle utility standards and trees of average circumference with no difficulty.

10. Batteries: The battery pack which is used in the Monitor is extremely difficult to construct -- it takes almost two man days for NBS personnel to construct one pack. Therefore, in order to save time, it is recommended that a battery system which can more easily be replaced be substituted for the one currently being used.

11. Switch guard: It is recommended that the Monitor switch be covered with a guard, so that if it is inadvertently hit, the Monitor will not be turned off prematurely.

12. Events > 80 dB: As the Monitor is now designed, it registers any noise events greater than 80 dB which have a duration of one second or more. It is believed that many spurious events thus tended to be registered as part of the data. To prevent this occurrence, it is recommended that for events greater than 80 dB, the effective duration be increased from one second to ten seconds.

13. Windsensor connector: It is recommended that the windsensor connection be redesigned both to facilitate ease of operation and to reduce the wear and tear to this point of the system.

4. REFERENCES

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[2] Fisher, R. L., Blomquist, D. S., Forrer, J. S., and Corley, D. M., A minicomputer-based system for the measurement and analysis of community noise, NBSIR 75-692 (National Bureau of Standards, Washington, D. C., May 1975).

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5. APPENDIX A

Performance Specification for an Urban Noise Exposure Measurement System

1. BACKGROUND

These performance specifications are for a complete portable urban noise exposure measurement system for use in enforcing the U. S. Department of Housing and Urban Development Circular 1390.2, Noise Abatement and Control: Departmental Policy, Implementation Responsibilities, and Standards. This policy statement establishes specific requirements for noise abatement and control which govern approval of projects under all Departmental programs. In this policy statement, the following interim standards are established:

External Noise Exposures: Sites for New Residential Construction (single or multifamily)

General External Exposures

Unacceptable

Exceeds 80 dB(A) 60 minutes per 24 hours

Exceeds 75 dB(A) 8 hours per 24 hours

Discretionary -- Normally Unacceptable

Exceeds 65 dB(A) 8 hours per 24 hours

Loud repetitive sounds on site

Discretionary -- Normally Acceptable

Does not exceed 65 dB(A) more than 8 hours per 24 hours

Acceptable

Does not exceed 45 dB(A) more than 30 minutes per 24 hours

Interior Noise Exposures: For New and Rehabilitated Residential Construction.

Sleeping Quarters

Acceptable

Does not exceed 55 dB(A) 60 minutes per 24 hours

Does not exceed 45 dB(A) 30 minutes between 11 p.m. to 7 a.m.

Does not exceed 45 dB(A) 8 hours per 24 hours.

Note: All A-weighted sound levels referred to in Policy Circular 1390.2 and in this performance specification are relative to a reference sound pressure of 20 micropascals.

The Department of Housing and Urban Development has published noise assessment guidelines that are used as site screening tools. These guidelines provide the means for separating sites that are clearly acceptable from those clearly unacceptable. Resolution of appellate applications, or of cases where the site classification is indeterminate, requires a means for instrumental measurement of physical data. These performance specifications are for a measurement system to classify a building site relative to the interim standards cited above.

The National Bureau of Standards has developed and field tested prototype instrumentation to implement measurements against Interim Standards; while all details of this system will be made available to the contractor, it is the contractor's responsibility to determine that these performance specifications are met.

2. INSTRUMENTATION SPECIFICATIONS

The instrumentation system shall consist of a "Monitor", which is to be left at the desired location for at least 24 hours and a "Reader", which interrogates the Monitor. The basic Monitor (see Sec. 2.1) shall be designed specifically to collect the data required for characterizing the noise exposure in terms of the above-cited external noise exposure standards. An attachment ("Time-of-Day Clock" -- see Sec. 2.3) to the Monitor shall enable its use for collection of the data required for characterizing the noise exposure in terms of the above-cited interior noise exposure standards. The Reader is a unit capable of interrogating the Monitor. The Reader provides printed output of the data (see Sec. 2.2).

2.1 Monitor Specifications

The Monitor shall be a self-contained, battery-operated unit, consisting of a mounting assembly, and electronic package, a microphone and a weather screen, capable of registering, on internal memory, the data specified in Sec. 2.1.8. There shall be no way to read the memory directly; this shall be possible only through use of the Reader.

The Monitor shall consist of six major modules: (1) amplifier and A-weighting network, (2) detector and quantization, (3) digital clock, (4) digital scaling, (5) memory, and (6) calibration. The Monitor also includes an acoustic calibrator and a microphone with windscreen.

2.1.1 Frequency Response

The System response to sound of random incidence, with the microphone mounted in its normal configuration relative to the Monitor, and with the wind and weather shield in place, shall be as shown in Table A-1 (relative to a

Table A-1. HUD Noise Measurement System response to random incidence sound.

Frequency* Hz	A-Weighting Relative Response dB	Tolerance dB
10	−70.4	+4, −∞
12.5	−63.4	+3.5, −∞
16	−56.7	+3, −∞
20	−50.5	±2.5
25	−44.7	±2
31.5	−39.4	±1.5
40	−34.6	±1.5
50	−30.2	±1
63	−26.2	±1
80	−22.5	±1
100	−19.1	±1
125	−16.1	±1
160	−13.4	±1
200	−10.9	±1
250	− 8.6	±1
315	− 6.8	±1
400	− 4.8	±1
500	− 3.2	±1
630	− 1.9	±1
800	− 0.8	±1
1000	0	±1
1250	+ 0.6	±1
1600	+ 1.0	±1
2000	+ 1.2	±1
2500	+ 1.3	±1
3150	+ 1.2	±1
4000	+ 1.0	+1
5000	+ 0.5	+1.5, −2
6300	− 0.1	+1.5, −2
8000	− 1.1	+1.5, −3
10000	− 2.5	+2, −4
12500	− 4.3	+3, −6
16000	− 6.6	+3, −∞
20000	− 9.3	+3, −∞

The maximum deviation of the free-field relative response level as a function of angle of incidence with respect to the random incidence response level shall not exceed the values given in Tables A-2 and A-3.

*Nominal frequencies. Exact frequencies, to be used for design and test, are generated using $f = 1000 \times 10^{m/10}$ where m is a positive or negative integer.

Table A-2

Maximum allowable deviation of free-field relative response level with respect to random-incidence relative response level when the angle of incidence is varied from 45° to 90° from the axis about which the response is most nearly cylindrically symmetrical.

These allowances are added arithmetically to the respective tolerance limits in Table 1.

Frequency Hz	Allowance dB
31.5 to 2000	+1, -1
2000 to 4000	+1.5, -1
4000 to 5000	+2, -1.5
5000 to 6300	+2.5, -2
6300 to 8000	+3, -2.5
8000 to 10000	+3.5, -3.5
10000 to 12500	+4, -6.5

Table A-3

Maximum allowable deviation of free-field relative response level for sounds arriving at any angle of incidence with respect to random-incidence relative response level for any angle of incidence

These allowances are added arithmetically to the respective tolerance limits in Table 1.

Frequency Hz	Allowance dB
31.5 to 2000	+1.5, -1
2000 to 4000	+2.5, -2
4000 to 5000	+3.5, -3
5000 to 6300	+4, -4
6300 to 8000	+5.5, -5.5
8000 to 10000	+6.5, -8
10000 to 12500	+7.5, -11

frequency of 1000 Hz), within the tolerances indicated.

At frequencies below 10 Hz, the omnidirectional response of the system shall decrease with decreasing frequency at a rate equal to or greater than 12 dB per octave. At a frequency of 32 kHz, the omnidirectional response of the system shall be less than that at 1 kHz by an amount equal to or greater than 12 dB. At frequencies above 32 kHz, the omnidirectional response of the system shall decrease with increasing frequency at a rate equal to or greater than 12 dB per octave.

2.1.2 Amplifiers and Weighting Network

With an equivalent electrical impedance substituted for the microphone, the internal noise of the entire system shall be the equivalent of 35 dB(A) or less, and the equivalent of a 85 dB(A) signal shall produce less than 5% harmonic distortion.

2.1.3. Clock

The self-contained clock shall have an inherent uncertainty of less than 36 seconds in 24 hours. The maximum total coast error, i.e., error due to starting and stopping, shall be less than 36 seconds for a cycle of 10 seconds on, 10 seconds off, over a test period of 24 hours. The clock shall cause the monitor to sample the noise level every 2.2 milliseconds. The clock shall stop the sampling after 24.00 ± 0.01 hour.

2.1.4 Detector and Clock Gates

The RC time constant of the detector shall be .125 ± .02 seconds.

The detector and gates which control the clock registers shall activate the registers at the root-mean-square amplitudes of 45 ± 0.5, 55 ± 0.5, 65 ± 0.5, 75 ± 0.5 and 80 ± 0.5 dB(A) for the following signals:

1. sinusoidal signal at 1 kHz.

2. Gaussian noise at any equivalent amplitude between 45 and 80 dB(A).

3. Tone burst having a frequency of 100 Hz and a duty cycle of 10%.

A separate gate (from that used to activate a clock register) shall be used to activate the register indicating how many times the noise level exceeded 80 ± 0.5 dB(A). This gate shall have a time constant of 10 ± 1 sec.

2.1.5 Wind and Weather Screen

The microphone shall be provided with a weather shield and wind screen to permit operation in inclement weather. This shield shall be such that the equivalent noise is less than 55 dB(A) for winds up to 40 km (25 mph) and, in the absence of rain, shall charge the sensitivity of the microphone less than

±1 dB over the frequency range 20 Hz to 10 kHz and less than ±2 dB over the frequency of 20 Hz to 20 kHz. During rain at a rate up to 1.27 cm (0.5 inch) per hour the sensitivity of the microphone shall be changed less than ± 2 dB over the frequency range 50 Hz to 1 kHz and less than ±3 dB over the frequency range 1 kHz to 20 kHz.

A 10 cm (4 inch)* in diameter open cell polyurethane windscreen shall also be provided.

2.1.6 Wind Sensor

The Monitor shall be equipped with a wind speed transducer sensor which shall activate a clock register when the wind exceeds 40 ± 10 km/hr (25 ± 6 mph). This shall be connected to the Monitor with a Military Standard MS3102E connector.

The windsensor, when subjected to a rain at a rate of 1.27 cm (0.5 inch) per hour, but no wind, shall have a contact resistance of at least 100 k ohms.

2.1.7 Calibration and System Checkout

The Monitor shall include a separate acoustic calibration device which shall have an acoustic output of 80.5 ± .3 dB at a frequency of 1 kHz.

When the power is turned on, all memory in the Monitor shall be reset to zero. The Monitor shall be equipped with a switch-activated go/no-go indicator for battery charge. For a go indication the batteries shall have sufficient charge for powering the Monitor such that all specifications are met for 36 hrs. of continuous operation. The Monitor shall be provided with a means for making up to 5 dB changes in amplifier gain. When the acoustic calibration device is in place and activated, an indicator shall indicate one of the following conditions: (1) gain is too small, (2) gain is correct, or (3) gain is too large. Circuitry shall be provided to set an internal gate when the Monitor is correctly calibrated to within ±0.3 dB. The Monitor shall be equipped with a "data-start" pushbutton and indicator. Data acquisition cannot be started nor a data transfer made unless the following steps have been performed in sequence: (1) power on, (2) battery check, and (3) valid acoustic calibration has been performed.

The Monitor shall have circuitry to determine that, after 24 hours, a second calibration has been performed at 80.5 ± 1.0 dB. If the calibration is not within this tolerance, it shall not be possible for the Monitor to transfer data to the Reader.

2.1.8 Memory Registers

For both indoor and outdoor applications, the Monitor shall store the following information in digital form on internal memory registers:

-- an identification number (in permanent memory) unique to each Monitor unit

-- the accumulated times (to the nearest 0.01 hr.) that the noise level exceeded 45, 65, 75 and 80 dB(A), respectively, during the 24-hour monitoring period

-- the accumulated time (to the nearest 0.01 hr.) that the noise level was less than 45 dB(A) during the 24-hour monitoring period.

For outdoor applications, the Monitor shall store the following additional information in digital form on internal memory registers:

-- the number of times (to the nearest integer) that the noise level exceeded 80 dB(A) during the 24-hour monitoring period

-- the accumulated time (to the nearest 0.01 hr.) that the wind speed exceeded 40 km/hr.

For indoor applications, the Monitor shall store the following additional information in digital form on internal memory registers:

-- the accumulated time (to the nearest 0.01 hr.) that the noise level exceeded 55 dB(A) during the 24-hour monitoring period

-- the accumulated time (to the nearest 0.01 hr.) that the noise level exceeded 45 dB(A) between 2300 and 0700 hours.

2.1.9 Power Supply

The Monitor shall be provided with its own power supply consisting of rechargeable batteries (power pack) and sufficient power to enable 36 hour operation. The battery power pack shall be constructed such that individual cells may be replaced by the use of hand tools. The batteries shall be located in a separate chamber which is tightly sealed from the chamber containing the electronic circuitry. However, the power pack shall be constructed such that one cell may be replaced by using only hand tools. The Monitor also shall be provided with a battery charger, as a separate unit, which is capable of recharging the power pack from a fully discharged state to a fully charged state in a period of 14 hours. The battery charger shall operate from normal 115V, 60 Hz, electrical lines.

The Monitor shall be designed so that the power pack batteries can be changed readily. One extra battery pack shall be furnished with each Monitor unit.

The power pack provided with the Monitor shall, when fully charged, enable operation for a period of 36 hours.

2.1.10 External Connections

The Monitor shall be provided with Military Standard MS3102E external connectors for coupling to the Reader, and for connecting the microphone and wind speed sensor to the Monitor.

2.1.11 Mechanical Specifications

The Monitor, including the power pack, shall have a volume of less than .0071 m^3 (0.25 ft^3) and weigh less than 3.63 kg (8 lb), exclusive of the wind and weather shield for the microphone, and the mounting system.

The Monitor shall be contained in a case which meets or exceeds requirements of MIL-T945 specifications except Paragraph 3.51.2.4. All external devices, such as wind sensor and microphone mounting system, shall be the same color as the case. The lid of the case shall contain a clip for holding a screwdriver for gain adjustment of the Monitor. The mounting shall be designed to minimize acoustical reflections from the fixed object and the mounting device itself. The mounting shall be of such size and construction that it can be used conveniently by one person. The mounting shall include clamps for mounting to fixed objects, 7.62 to 30.5 cm (3 to 12 inches) in diameter. These clamps shall be able to be interconnected for mounting to larger diameter objects.

To minimize chances of dropping the Monitor a shock cord, or cords, shall be provided for temporarily attaching the Monitor to a fixed object 10 to 92 cm (4 to 36 inches) in diameter while clamps are being secured for a more permanent mounting.

The Monitor shall include a goose neck 30 to 46 cm (12 to 18 inches) long for mounting the Microphone to the case.

The Monitor shall be equipped with a polyethylene foam envelope 5 cm (2 inches) thick for covering the Monitor case. The envelope shall have cut-outs for the Microphone and windscreen. This envelope shall completely cover the Monitor and be equipped with a tape closure for fixing it to the case.

The power switch shall be enclosed by a cylindrical switch guard that has a height that is 90% of the height of the power switch.

2.1.12 Environmental Specifications

Temperature and Humidity -- The Monitor shall operate over the temperature range -20 to +60 °C with a change in overall sensitivity of not more than ±0.5 dB. The effect of changes in relative humidity on the response of the Monitor shall be less than ±0.5 dB in the range 5 to 90% R.H. The Microphone shall be constructed of corrosion resistant materials such that a 60 day exposure to 100% relative humidity at 25 °C will change the frequency response by less than 0.1 dB in the frequency range 20 Hz to 20 kHz.

Magnetic Field -- With the microphone connected to the Monitor, a magnetic field strength of 80 ampere per meter in the frequency range 50 to 500 Hz shall produce the equivalent of no more than 30 dB(A) for any orientation of the Monitor relative to the magnetic field.

Vibration -- With a vibration-insensitive equivalent electrical impedance substituted for the microphone, the effect of 1 sinusoidal acceleration along each of three mutually orthagonal axes of the Monitor in the frequency range 63 to 4000 Hz, or of a shock load of 30 g's, 1/2 sine, 11 milli-second duration, shall be less than the equivalent of 30 dB(A). The vibration sensitivity of the microphone shall not exceed 100 dB (re 20 micropascals) at any frequency in the range 63 to 4000 Hz for a 1 g sinusoidal acceleration along each of three mutually orthagonal axes.

With the Monitor enclosed in the polyethylene envelope, and the Microphone and wind sensor removed, the Monitor shall not be damaged by a 4.57 m (15 foot) drop along each of three mutually orthogonal axes.

Airborne Noise -- The Monitor, including the microphone and all electronics, when in operation, shall not be damaged by continuous exposure to airborne noise at a level of 140 dB(A). When the Monitor is exposed to a pure tone sound at any frequency over the range 10 to 20,000 Hz and at any level over the range 45 to 80 dB(A), or when the Monitor is exposed to an octave band of Gaussian noise at any center frequency in the range 63 to 8000 Hz, the detected signal shall be at least 20 dB greater than that under the same conditions and in the same sound field when the microphone is replaced by an equivalent electrical impedance.

2.2 Reader Specifications

The Reader shall be a self-contained, battery-operated unit capable of interrogating and providing a permanent record of data stored in the Monitor. It shall include interconnections such that the Reader cannot be powered until it is connected to the Monitor. The Reader shall include the necessary logic to perform the following functions: (1) Calibration interrogation, (2) Monitor-malfunction interrogation, (3) data transfer. It shall include a read-start switch, a no-calibration indicator, a Monitor-malfunction interrogation and a data-transfer-complete indicator. The Monitor-malfunction interrogation shall be a check of the internal consistency of the data stored in the Monitor.

When the read-start switch is activated, the Reader shall produce, on an internally-contained printer, hard copy indicating one of the following three situations:

1. Unsatisfactory calibration
2. Monitor-malfunction
3. Data transfer complete.

If data transfer is effected, the Reader shall then produce, on its printer, the following data as transferred from the Monitor:

1. The accumulated time that 80 dB(A) was exceeded.

2. The accumulated time that 75 dB(A) was exceeded.

3. The accumulated time that 65 dB(A) was exceeded.

4. The accumulated time that 45 dB(A) was exceeded.

5. The number of times 80 dB(A) was exceeded.

6. The accumulated time the wind was greater than 20 knots.

7. The Monitor identification number.

During indoor applications, with the Time of Day clock connected, accumulated time that 45 dB(A) was exceeded between 23:00 and 07:00 hours shall be transferred instead of the number of times 80 dB(A) was exceeded, and the accumulated time that 55 dB(A) was exceeded shall be transferred instead of the total time the wind speed was greater than 40 km/hr.

The Reader shall print a unique symbol at the beginning and end of the data in order to minimize the possibility of falsification of data.

2.2.1 Reader Accuracy

The Reader shall print out all times to the nearest 0.01 hr. and the number of times 80 dB(A) was exceeded to the nearest integer.

2.2.2 Printer

The printer shall consist of at least a 5 x 5 matrix and produce easily readable hard copy while the Reader is in any orientation.

2.2.3 Power Supply

The Reader shall be provided with its own rechargeable power pack and suitable voltage control. The batteries shall be located in a separate chamber which is tightly sealed from the chamber(s) containing the electronic circuitry and the printer. The Reader shall be provided with a battery charger, which is capable of recharging the power pack from a fully discharged state to a fully charged state in a period of 14 hours. The batteries shall not have to be removed for charging. The battery charger shall operate from normal 115V, 60 Hz, electrical lines.

The Reader shall be provided with an indicator to determine the state of charge of the power pack is sufficient to enable the Reader to interrogate the Monitor two times.

The power pack provided with the Reader shall, when 80 percent charged, enable 10 Monitor interrogations to be effected without necessity for recharging at a temperature of 5°C.

2.2.4 External Connections

The Reader shall be provided with a Military Standard MS3102E connector for coupling to the Monitor. The Reader shall use the same connector for battery recharging.

2.2.5 Mechanical Specifications

The Reader, including the power pack, shall occupy a volume of less than .014 m^3 (0.5 ft) and weigh less than 4.53 kg (10 lb).

2.2.6 Environmental Specifications

Temperature and Humidity -- The accuracy or functional capabilities of the Reader shall not be affected by temperatures in the range of 0 to 60 °C or relative humidity in the range of 5 to 100% R.H.

Rain -- The Reader shall be enclosed such that it will not be damaged in a rain storm of 10 cm (4 inch) per hour.

Magnetic Field -- With the Reader connected to the Monitor, a magnetic field strength of 80 ampere per meter in the frequency range 50 to 500 Hz shall not affect the accuracy or functional capabilities of the Reader.

Vibration -- The operation of the Reader shall not be affected by a 1 g sinusoidal acceleration along each of three mutually orthogonal axes of the Reader in the frequency range of 63 to 4000 Hz, or by a shock load of 30 g's, 1/2 sine, 11 milli-second duration.

2.3 Time of Day Clock Specifications

The Time of Day clock shall be a self-contained, battery-operated unit capable of providing the necessary logic to the Monitor to enable the 45 dB(A) memory register between 2300 and 0700 hrs. The clock shall include provisions for setting units of minutes, tens of minutes, units of hours and tens of hours.

2.3.1 Clock Accuracy

The clock shall have an uncertainty of less than 36 seconds in 24 hrs.

2.3.2 Time Readout

The time readout shall be of the 24:00 hrs. type. The display shall be of the segmented type such that a failure of one element cannot be read as a different number; e.g., an "8" cannot be read as a "6" or "9" due to failure of one element of the display. To conserve battery power the display shall only be powered during setting of the time of day.

2.3.3 Power Supply

The clock shall be provided with its own rechargeable power pack and suitable voltage control. The batteries shall be located in a separate chamber which is tightly sealed from the chamber(s) containing the electronic circuitry. The clock also shall be provided with a battery charger, which is capable of recharging the power pack from a fully discharged state to a fully charged state in a period of 14 hours. The batteries shall not have to be removed for charging. The battery charger shall operate from normal 115V, 60 Hz, electrical lines.

The clock shall be provided with an indicator to determine that the state of charge of the power pack is sufficient to power the clock for 24 hours.

The power pack provided with the clock shall, when 80 percent charged, enable 36 hours of operation.

2.3.4 External Connections

The clock shall be provided with a connector to mate with the Monitor. The clock shall also be provided with a connection to mate with the Reader such that the clock need not be disconnected for the Reader to interrogate the Monitor.

2.3.5 Mechanical Specifications

The Reader, including the power pack, shall occupy a volume of less than 5.66 cc (0.2 ft^3) and weigh less than 1.36 kg (3 lb).

2.3.6 Environmental Specifications

Temperature and Humidity -- The accuracy of functional capabilities of the clock shall not be affected by temperatures in the range of 0 to 60 °C or relative humidity in the range of 5 to 100% R.H.

Magnetic Field -- With the clock connected to the Monitor, a magnetic field strength of 80 ampere per meter in the frequency range 50 to 500 Hz shall not affect the accuracy or functional capabilities of the clock.

Vibration -- The operation of the clock shall not be affected by a 1 g sinusoidal acceleration along each of three mutually orthogonal axes of the Reader in the frequency range of 63 to 4000 Hz, or by a shock load of 30 g's 1/2 sine, 11 milli-second duration.

2.4. Transit Case

The system shall include a Transit Case. The Transit Case shall include provisions for shipping the following items:

(1) Monitor with Microphone and Mounting Device

(2) Calibration Device

(3) Wind Sensor

(4) Battery Chargers

(5) Reader

(6) Windscreens

A carrying case shall be provided for transportation of the mounting tools and materials.

2.4.1 Mechanical Specifications

The Transit Case shall be of a size and dimensions that it may be shipped as luggage by all domestic airlines.

The case shell shall be constructed of deep drawn 2024 aluminum alloy, heat treated at least 100 mm (.040 inch) thick. The closure for the case shall be interlocking tongue and groove extrusion of 6063-T5 aluminum alloy bonded to case, and shall include a neoprene gasket seal. The case hinge shall be of the piano type (continuous) aluminum and riveted to the case. Case latches shall be positive locking bale. The case shall be lined with (2 lbs) polyurethane foam with cutouts for the items contained therein.

2.4.2 Environmental Specifications

Rain -- The Transit Case shall not leak water when subjected to a rain of 10 cm (4 inch) per hour.

Vibration -- The contents of the Transit Case shall not be damaged when dropped 3 m (10 feet) along each of three mutually orthogonal axes of the case.

HUD'S NOISE MEASUREMENT SYSTEM

CAUTION: The microphone is a delicate instrument and you are cautioned to avoid bumping or dropping it. The windscreen should be kept over the microphone to avoid damage.

PREPARATION IN THE OFFICE

This section contains instructions for an inventory check of parts needed for mounting, and for checks of batteries and damage to the windsensor. These checks should be performed in the office prior to leaving for the site.

Inventory Check

For mounting the system, check to see if you have the following parts:

1. Monitor
2. Calibrator
3. Windscreen
4. Windsensor
5. Banding Material*
6. Buckles*
7. Banding Tool*
8. Hammer*
9. Polyurethane Cover
10. Tape*
11. Shock Cord

*Items not shown in illustration.

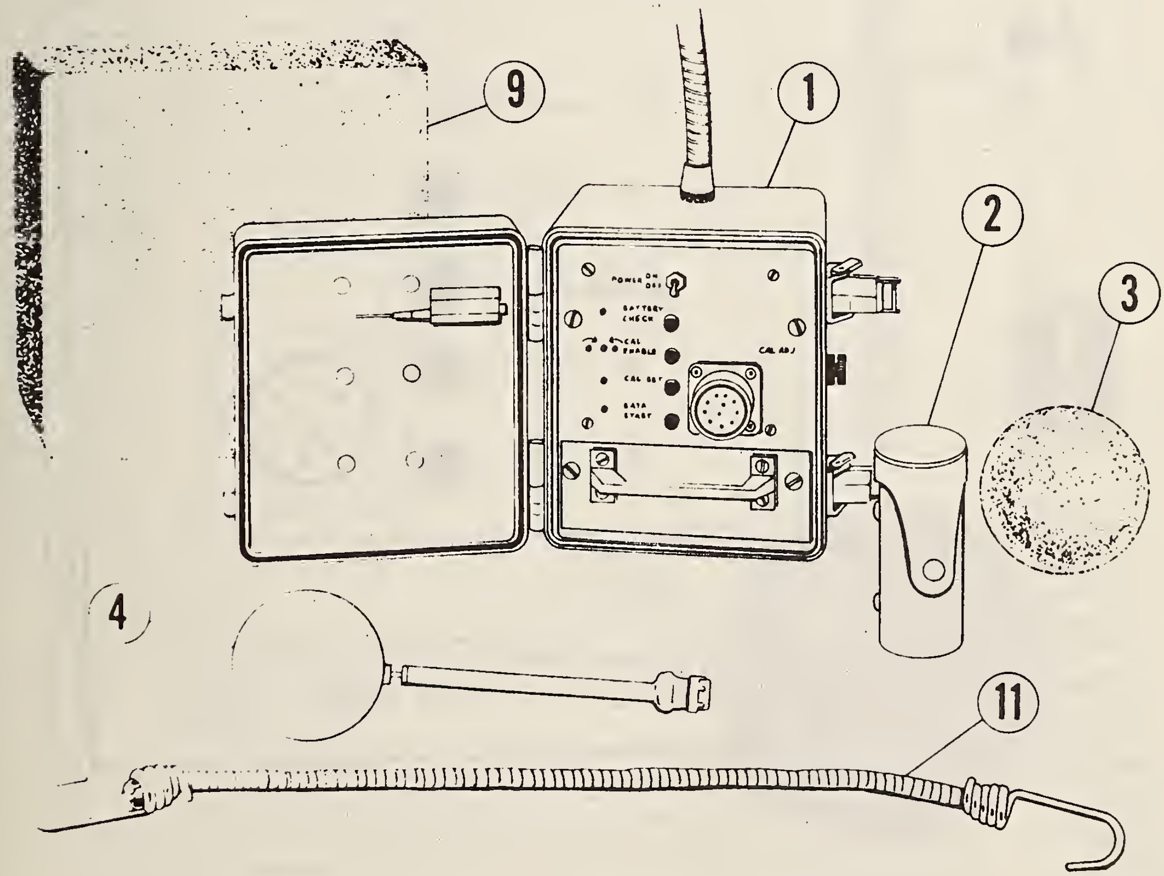


FIGURE 1

Microphone Check

Look into window of microphone dessicator and check color of powder of the dessicator. If it has turned from blue to light pink, the dessicator must be baked. See MAINTENANCE.

Monitor Battery

When not in use, one of the Monitor batteries should be charged. To charge the battery, connect it to the Monitor Battery Charger. Connect the charger to an ac outlet and then turn it "ON". The battery should be charged a minimum of 14 hours. The battery cannot be overcharged.

Monitor Battery Check

1. Open the Monitor case by pulling on the two case latches.
   WARNING: These latches are spring loaded. Be sure to keep your fingers out of the way.
2. Turn the POWER "ON".
3. Depress the BATTERY CHECK pushbutton. If the green light to the left of the "BATTERY CHECK" is on, the batteries are charged. If not, do the following.
   a. Turn the POWER "OFF".
   b. Remove the two wing screws next to the handle below the pushbuttons and place them in the case lid.
   c. Remove the "BATTERY" case by pulling straight out on the handle while holding the Monitor case.
   d. Insert a new "BATTERY" by pushing down on the handle.
   NOTE: The "BATTERY" label should be facing the switches. Check the battery by going to Step 2. If this battery fails the battery check test, both batteries need to be charged.

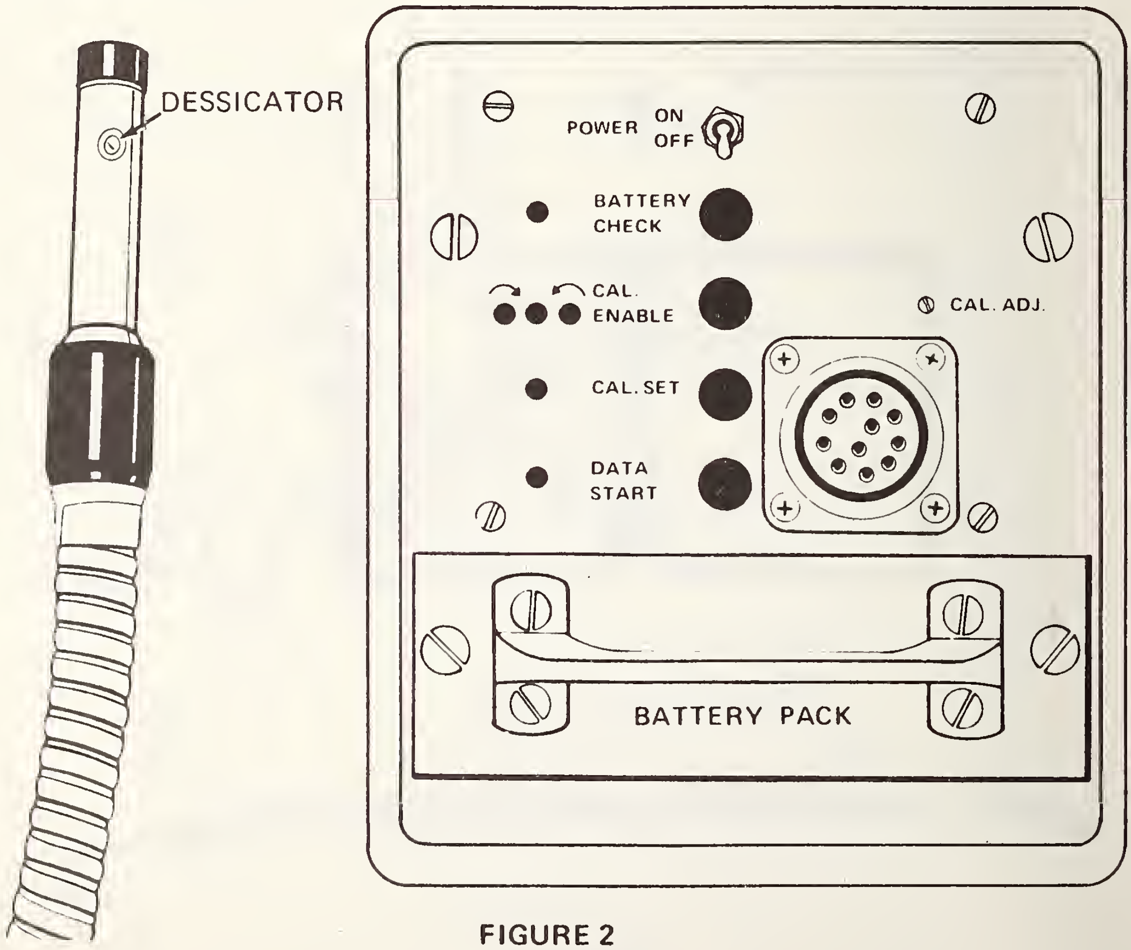


FIGURE 2

Calibrator Battery Check

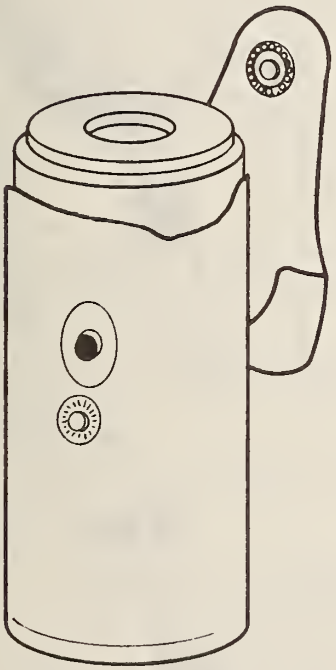
Unsnap the top leather cover of the acoustic calibration device and depress and then release the pushbutton on the side. You must hear a tone, and this tone should last at least 45 seconds to indicate adequate charge. If not the battery must be replaced with a new 9 volt transistor radio battery available at most drug stores. Use the following procedure.

1. Remove the leather cover from the calibrator.
2. Unscrew the bottom battery cover. This cover is on the opposite end from the opening.
3. Unsnap the battery terminals and replace the battery.
4. Recheck the battery. If the battery does not pass the battery check, recheck the connections.
5. Assemble the battery cover and the calibrator cover.

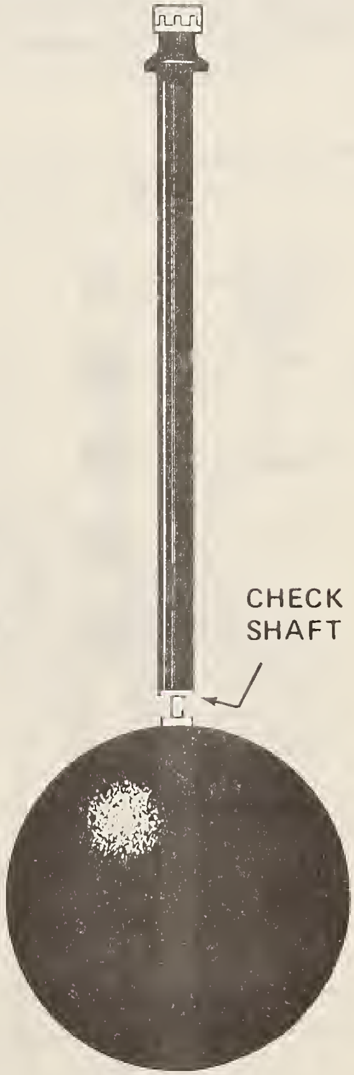
Windsensor Check

Visually check the windsensor for damage by gently pushing the ball to the sides of the tube to see that the shaft is not binding against the sides of the tube.

CAUTION: If the shaft is binding against the sides of the tube, the windsensor is damaged and the data obtained from the NMS will not be valid.



CALIBRATION DEVICE



WINDSENSOR

FIGURE 3

CALIBRATION

This section contains the instructions for calibration of the Monitor. If the time required to reach the site is 2 hours or less, this may be performed in the office. (See Figure 4 for the location of controls.)

1. Open the Monitor case.
2. Turn the POWER "ON".
3. Depress the "BATTERY CHECK" button. If this light is on, proceed. If not, change the battery.
4. Remove the windscreen. Place the calibrator over the microphone and push it down.
5. Depress and then release the pushbutton on the calibrator.
   NOTE: If the operations below take more than 45 seconds, the pushbutton must be depressed again since the calibrator will turn itself off.
6. Depress the CAL ENABLE pushbutton. Hold the button in the depressed position. If a red light goes on, continue to depress the CAL ENABLE button and turn the calibrator adjust screw in the indicated direction until the center green light goes on.
   NOTE: If the screw has been turned twenty turns and the center light is not on, check to see that the calibrator is still on.
7. Depress the CAL SET pushbutton. The green light will come on if step 6 has been performed successfully, and the calibrator is still on.
8. Remove the calibrator and replace the windscreen.

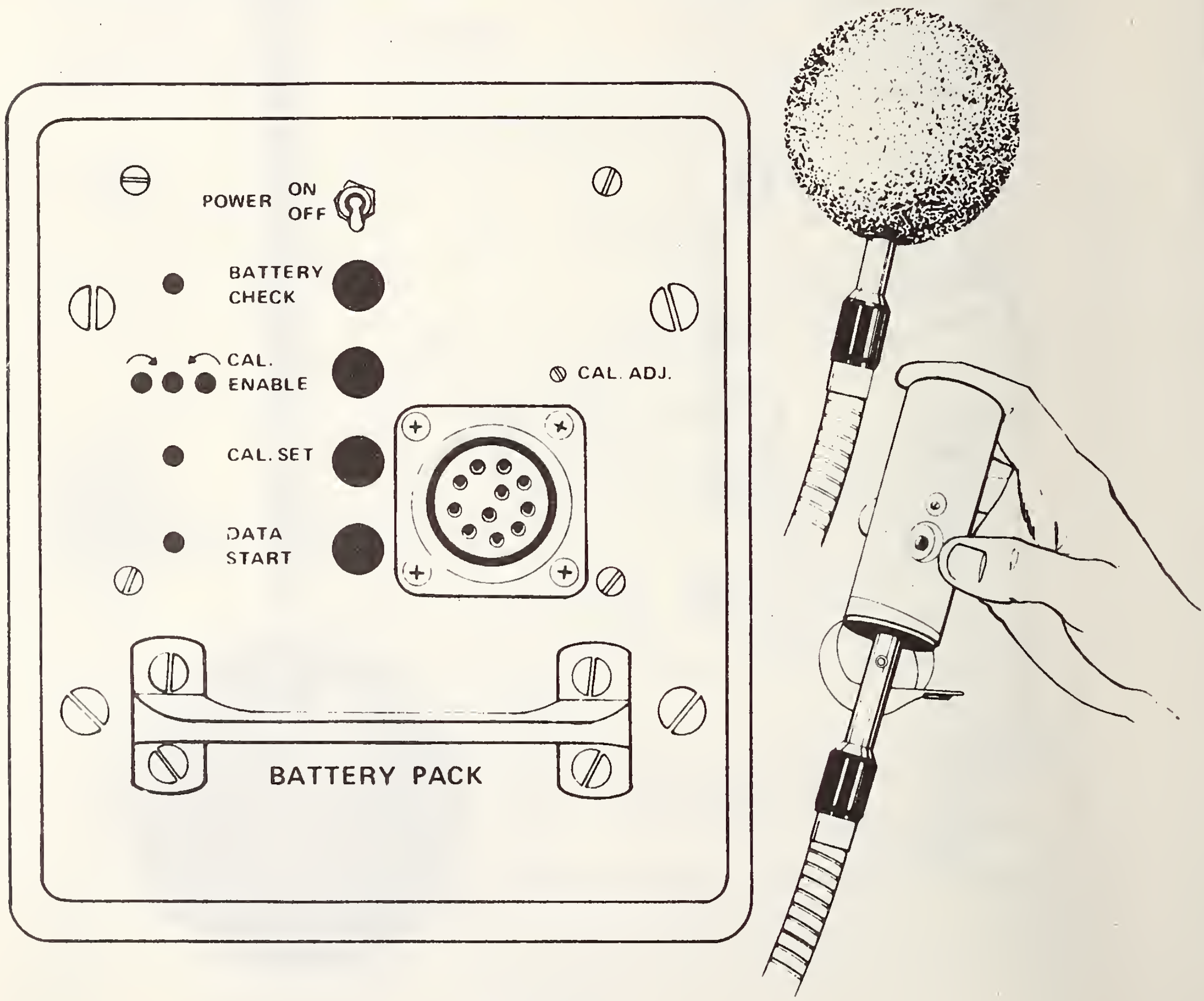


FIGURE 4

MOUNTING

This section contains instructions for mounting the Monitor, at the site. The Monitor is designed to be mounted on a utility pole or other pole and secured according to instructions on banding material box for use of banding material. If a utility pole is not used, see the Appendix for instructions.

1. Cut band 5 inches longer than the distance around pole. Thread band through buckle for at least ¾ in. and bend band back under buckle. Cut the band using the front handle on the tool.
2. Thread the band through the slots in the foam cover and through both loops on the back of the Monitor.
3. With the microphone pointing up, temporarily clamp the Monitor in position with the shock cord. The cord should pass through the handle.
4. Clamp the Monitor to the pole by turning the handle.
   CAUTION: Turn the handle until the polyurethane cover has just started to deform. BE CAREFUL NOT TO DEFORM THE METAL CASE.
5. Rotate tool over buckle, backing off gradually with tension handle through entire course of bend. Cut any surplus material.
6. Mount the windsensor by plugging it in the connector and turning it to the right.
7. Move the microphone away from the pole by bending the goose neck as shown in Figure 6.
8. Remove the shock cord and depress the DATA START pushbutton. When the Data Start Light turns on, data collection has started. If the green light does not go on, repeat the calibration procedure.
9. Close the cover and place the second half of the polyurethane cover over the Monitor. Secure the cover with tape all around the cover. Do this as quietly as possible.

This completes the mounting of the Monitor. It will collect data for the next 24 hours and then stop automatically. Data cannot be read before the 24 hour collection period, or after 36 hours.

At this time you should check the Reader batteries. See next page. If the batteries require charging, do so at this time.

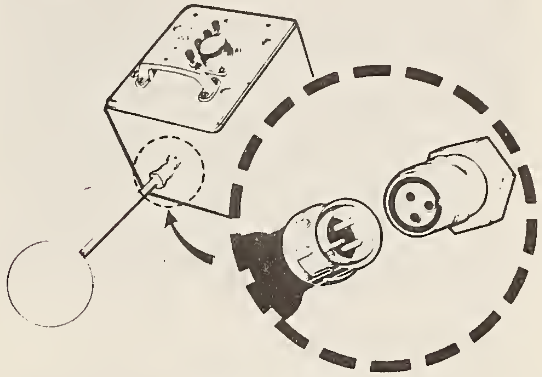


FIGURE 5

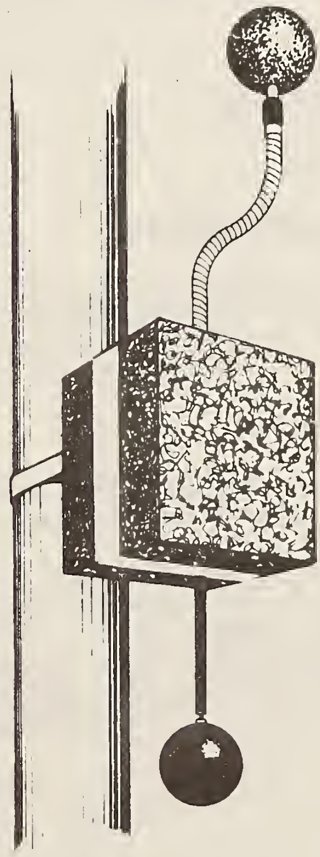


FIGURE 6

PREPARATION FOR DISMOUNTING THE MONITOR AND READING THE DATA

WARNING: Do not turn Monitor power off prior to completion of reading the data.

This section contains instructions for an inventory check of parts needed for dismounting the Monitor and reading the data and for checks on batteries in the Reader and Calibrator. These checks should be conducted in the office before leaving for the site. Remember, data from the Monitor cannot be read prior to 24 hours. Any attempt to read the Monitor prior to completion of the full 24 hour period will result in a meaningless zero answer. Data must be read before 36 hours have elapsed from the instrument turn on time.

Inventory Check

To remove the Monitor and read the data, check to see that you have the following:

1. Cutters
2. Shock Cord
3. Calibrator
4. Reader

Battery for the Readers

NOTE: The battery for the Manual Reader and Automatic Reader is contained in the case and cannot be removed.

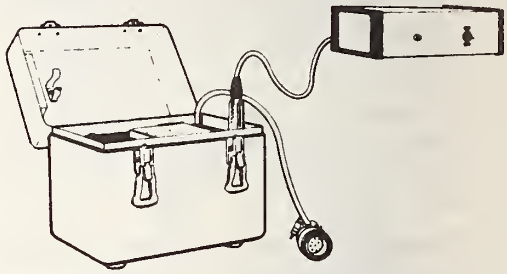
Manual Reader

The Manual Reader Battery should be charged. To charge do the following:

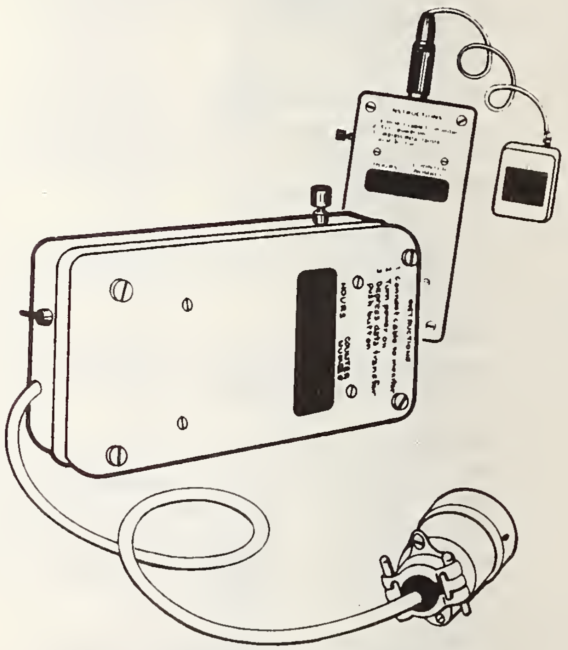
a. Turn the Reader Switch OFF.
b. Connect the Reader to the Reader Battery Charger.
c. Plug the charger into an "ac" outlet. The Reader must be charged a minimum of 14 hours; it cannot be overcharged.

To check the charge in the Manual Reader:

1. Turn the POWER of the Manual Reader "ON".
2. If the red light below "COUNTER NUMBER" comes on, the battery has sufficient charge to interrogate the Monitor.
3. If the red light below "COUNTER NUMBER" does not come on, the battery must be charged.



AUTOMATIC READER



MANUAL READER

FIGURE 7

Automatic Reader

The battery for the Automatic Reader should be charged after ten interrogations of the Monitor.

To charge:

a. Connect the Automatic Reader to the Reader Battery Charger.
b. Turn the Reader Power "OFF" and the Charger Power "ON".
c. Plug the Charger into an "ac" outlet for a minimum of 14 hours. The battery cannot be overcharged.

To check the charge in the Automatic Reader:

1. Turn the POWER switch of the Automatic Reader to "TEST".
2. If the red light on the Automatic Reader comes on, the battery has sufficient charge to interrogate the Monitor.
3. If the red light does not come on, the battery must be charged.

READING THE DATA

This section contains instructions for reading the data. Separate instructions are provided for the Manual Reader and the Automatic Reader.

WARNING: DO NOT TURN THE MONITOR POWER "OFF". If the power is turned "OFF" the data will be lost and a new measurement will have to be made.

FIGURE 8

*If the cal set light does not come on, check to see that the calibrator is working. If it is, the Monitor is defective and the data cannot be read.

Manual Reader

1. Remove the polyurethane cover, temporarily clamp the Monitor with the shock cord, remove the wind sensor, and then remove the Monitor from pole.
2. Open the lid and connect the Reader to the Monitor, and turn the Reader Power "ON".
3. Remove the windscreen, place the calibrator over the microphone and push it down until it seats over the microphone.
   WARNING: DO NOT depress the Cal Enable button on the Monitor.
4. Depress the pushbutton on the calibrator and then depress the "CAL SET" pushbutton. The cal set light will come on.*
5. Depress the data transfer pushbutton and release it. Record the data and counter number. Check to see that this number is correctly recorded. When the pushbutton is depressed again, the counter will be reset. Depress the pushbutton again and data for the next counter will be shown. Repeat this operation for all 8 encounters.
6. Turn the power to both units "OFF", disconnect them and replace the windscreen.

The register and the data are displayed as follows:

Counter	Interval (Decimal hours)
1	Greater than 80 dB(A)
2	75-80 dB(A)
3	65-75 dB(A)
4	45-65 dB(A)
5	Less than 45 dB(A)
6	Number of events over 80 dB(A)
7	Time that wind noise exceeded capability of windscreen
8	Serial number of Monitor

(Sequential addition of counters 1 through 5 is necessary before this data conforms to the format of HUD General Noise Standards.)

The data is in decimal hours, not minutes. To verify the data, total counters 1 through 5; the total must be 24 + .05 or the system has malfunctioned.

AUTOMATIC READER

The Automatic Reader interrogates the Monitor, performs checks on the status of the Monitor and prints out the data.

1. Remove the polyurethane cover, temporarily clamp the Monitor with the shock cord, remove the windsensor and remove the Monitor from the pole.
2. Open the lid and connect the Reader to the Monitor. Turn the Reader Power "ON".
3. Remove the windscreen, place the calibrator over the microphone and push it down until it seats over the microphone.
   WARNING: DO NOT depress the Cal Enable button on the Monitor.
4. Depress the pushbutton on the calibrator and then depress the "CAL SET" pushbutton. The cal set light will come on.*
5. Turn the power "ON". It will take the Reader approximately one minute to check the data during which time the only indication it is working is the pilot light will be on.
6. The Reader will print data as follows:
   The Reader first checks to see that a calibration was performed. If the system was not calibrated, "UC" is printed and the measurement must be repeated. The Reader then checks the rest of the Monitor, if a failure in the Monitor occurred in the 24 hour data collection period, a "MM" (Monitor Malfunction) is printed. If the system is operating correctly and was used correctly, data is printed in the following sequence:

   Counter

   1 Monitor serial number
   2 Time greater than 80 dB(A)
   3 Time greater than 75 dB(A)
   4 Time greater than 65 dB(A)
   5 Time greater than 45 dB(A)
   6 Number of events greater than 80 dB(A)
   7 Time that wind noise exceeded capability of windscreen

The data as printed by the Reader is in decimal hours.

7. After the data are printed, turn the power to both units "OFF", disconnect them and replace the windscreen over the microphone.

*If the cal set light does not come on, check to see that the calibrator is working.

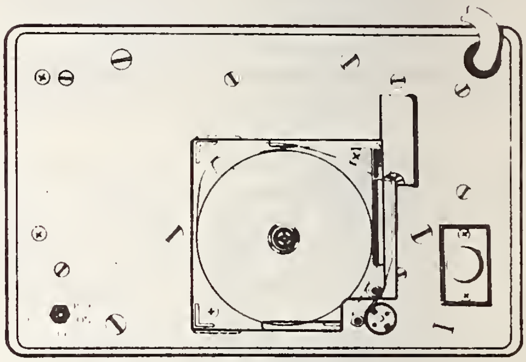


FIGURE 9

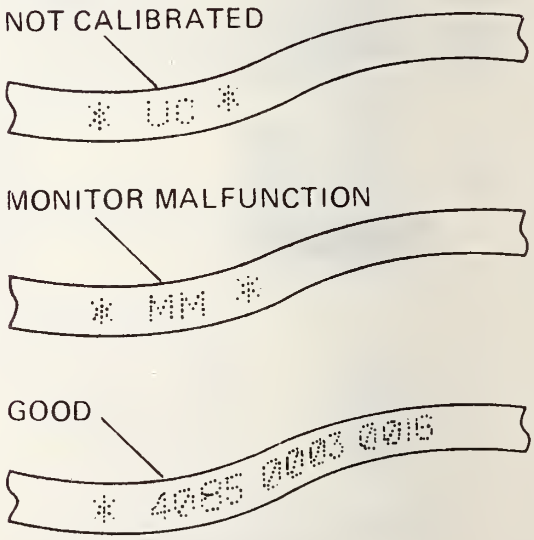


FIGURE 10

MAINTENANCE

The NMS requires little user maintenance beyond charging batteries.

The precision microphone, however, in this system can be affected adversely by high humidity. A dessicator, containing a water absorbing material, is attached to the microphone to keep it functioning properly. Periodically, the dessicator must be dried out by baking it in order to restore its effectiveness. The frequency that the dessicator must be baked will depend upon the relative humidity to which the Monitor is exposed. In very high humidity conditions, the dessicator should be checked after 72 hours of use. To check, remove the windscreen and look at the color of the powder through the small window. If the color has changed from blue to light pink, the dessicator must be baked.

WARNING: DO NOT DEVIATE FROM THE FOLLOWING INSTRUCTION. Any deviation will most probably destroy the microphone or dessicator. Not only would replacement be expensive, a replacement may take as long as 6 to 9 months. If there are any questions, do not attempt to bake the dessicator.

To bake the dessicator CAREFULLY use the following procedure:

1. Grasp the microphone just below the black plastic grid and unscrew it while holding the dessicator, place the microphone in a safe place.
2. Unscrew the dessicator.
3. Place only the dessicator in an oven heated to 200° F for 6 hours or more.

To assemble the units CAREFULLY use the following procedure:

1. Screw on the dessicator.
2. Grasp the microphone below the plastic grid and screw it on the dessicator.

APPENDIX

If a utility pole is not used, a fence post and auxiliary pole must be used.

1. Drive the fence post in the ground until the barbs on the bottom of the pole are just covered.
2. Place the auxiliary pole over the fence post.
3. Push the mounting bolt through the hole in the auxiliary pole and hole in the fence post.
4. Screw the bolt into the nut and go to step 1 of Mounting.

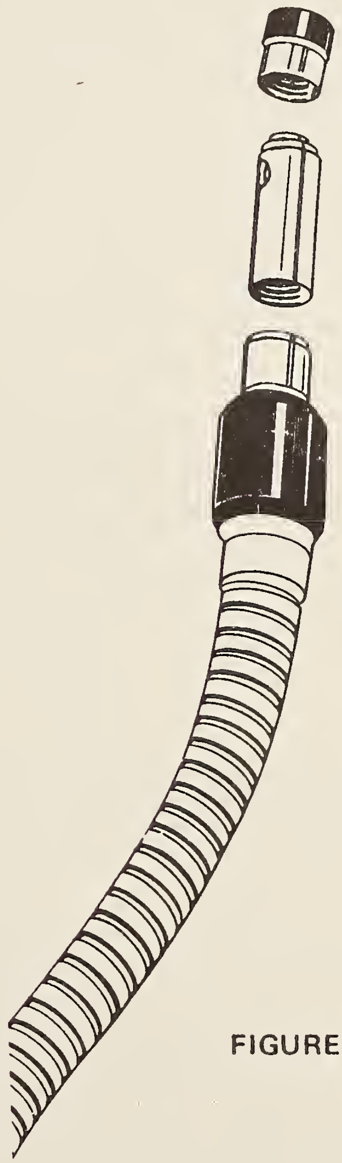


FIGURE 11

8. APPENDIX C

FIELD USE INSTRUCTIONS

THE HUD NOISE MEASUREMENT SYSTEM

INTRODUCTION

This manual provides information for the utilization of the HUD Noise Measurement System. It is a companion to the document entitled Operation Instructions the HUD Noise Measurement System. This system was developed to assist HUD in implementating its policy on noise abatement and control for general sites which are not impacted by airport noise.

Sites for HUD sponsored development must comply with the noise exposure standards contained in HUD Policy Circular 1390.2. In order to implement the standards, HUD Noise Assessment Guidelines were developed to enable personnel without acoustical training to perform preliminary estimates of the noise exposure of a site in relation to the HUD standards. The Guidelines are designed to be used as a screening device to indicate whether proposed sites may be exposed to excessive noise levels. When the use of the Guidelines indicates a potential noise problem in need of further resolution, it is wise to supplement existing information with actual noise measurements on the site.

The Noise Measurement System when used in accordance with the directions provided in the present manual will provide accurate data on the existing noise exposure of a site in accordance with HUD's General Noise Exposure Standards.

To facilitate the use of the present document, a brief summary of HUD Interim Standards are included in Table I. Note that only general exposure of sites which do not lie within a zone impact by airport noise are included since the present system is especially designed for general purpose only.

A brief summary is presented in the form of a flow chart in Table II which condenses the various steps involved in obtaining data with the HUD Noise Measurement System. This is then followed by a detailed step by step procedure for obtaining and interpreting the data from the HUD Noise Measurement System.

Where appropriate, examples are given on the right hand side of the page in *italic* type.

TABLE I

EXTERNAL NOISE EXPOSURES FOR NEW RESIDENTIAL CONSTRUCTION

IN A-WEIGHTED SOUND PRESSURE LEVELS

UNACCEPTABLE

Exceeds 80 dB(A) 1.00 hour per 24 hours
Exceeds 75 dB(A) 8 hours per 24 hours

DISCRETIONARY -- NORMALLY UNACCEPTABLE

Exceeds 65 dB(A) 8 hours per 24 hours
Loud repetitive sounds on site

DISCRETIONARY — NORMALLY ACCEPTABLE

Does not exceed 65 dB(A) more than 8 hours per 24 hours

ACCEPTABLE

Does not exceed 45 dB(A) more than 0.50 hours per 24 hours

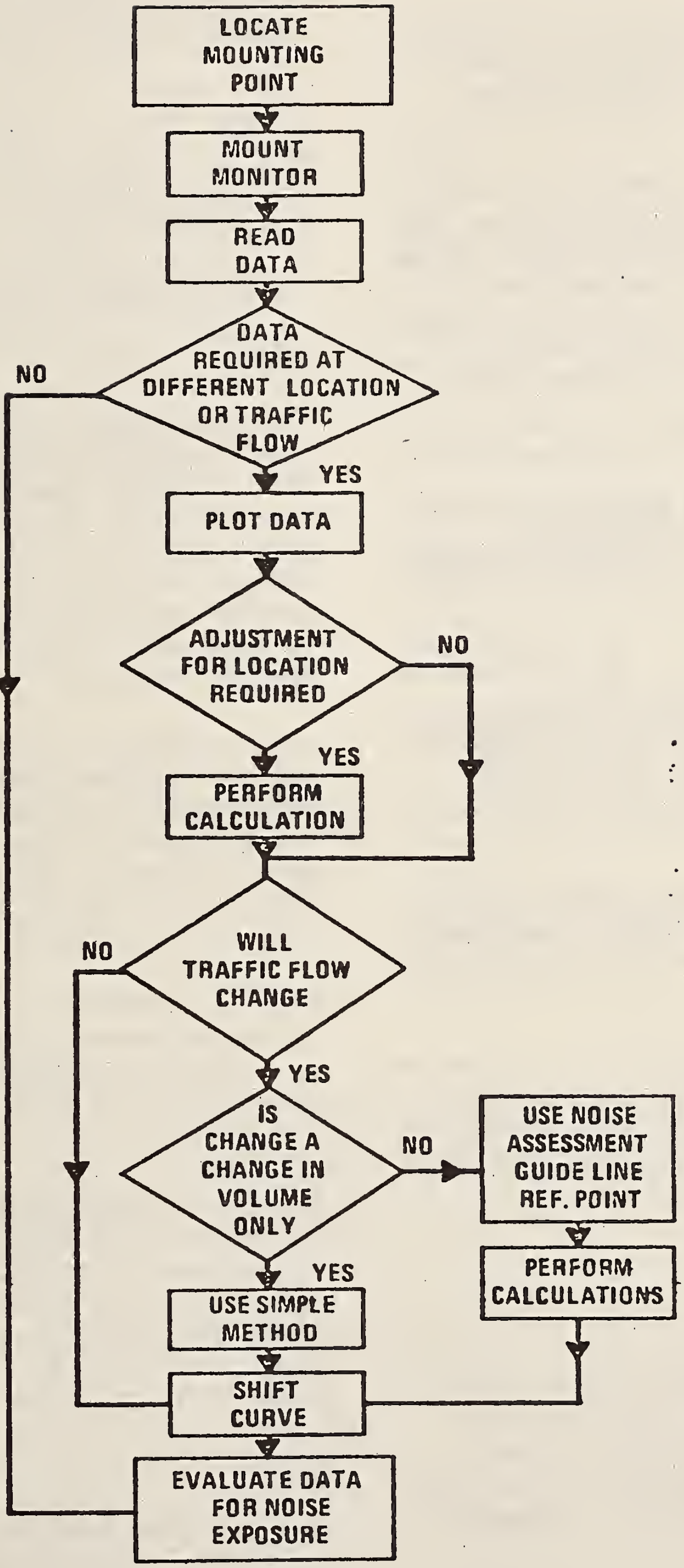


TABLE II FLOW CHART OF OPERATIONS

FINDING THE APPROPRIATE LOCATION AND MOUNTING THE MONITOR

STEP 1

Identify the best location for the Monitor according to the following procedure:

1.a. Walk around the site and listen for the noisiest location. Listen for traffic noise, truck-car mixture, stop and go traffic, and other sources of noise. If more than one point is found or the site is large, more than one measurement point may be appropriate.

STEP 2

In order to mount the Monitor you will need to refer to the OPERATING INSTRUCTIONS THE HUD NOISE MEASUREMENT SYSTEM.

2.a. If there is a utility standard at the location identified in Step 1.a. refer to the OPERATING INSTRUCTIONS - PREPARATION IN THE OFFICE and THEN MOUNTING. If there is no utility standard go to Step 2.c.

2.b. Draw a plan view of the site on the back of the data sheet. Indicate major noise sources and the location of the Monitor.

2.c. If there is no utility standard at the location identified in Step 1.a. refer to the OPERATING INSTRUCTIONS - APPENDIX for instructions on erecting a pole and then go back to 2.a.

READING THE DATA

STEP 3

In order to read the data refer to the OPERATING INSTRUCTIONS THE HUD NOISE MEASUREMENT SYSTEM. If the system contains an Automatic Reader go to Step 3.a. If the system contains a Manual Reader go to Step 3.b.

3.a. Refer to the OPERATING INSTRUCTIONS - READING THE DATA - AUTOMATIC READER, read the data from the Monitor and place the data tape on the Automatic Reader Data sheet.

3.b. Refer to the OPERATING INSTRUCTIONS - READING THE DATA - MANUAL READER, read the data from the Monitor and enter these data in the Manual Reader Data Sheet.

VALIDATING THE DATA

STEP 4

The data must be validated for correct operation of the Monitor and the time that the wind noise exceeded the capability of the windscreen. In the case of the Automatic Reader only the latter check must be performed. If the system contains an Automatic Reader go to Step 4.a. If the system contains a Manual Reader go to step 4.b. then 4.c.

4.a. Determine that the wind noise did not exceed the performance of the windscreen by checking that the wind noise counter is less then 1.00, if greater than or equal to 1.00 the test must be run again; therefore go back to Step 2. If less than 1.00 go to Step 5.

4.b. Determine that the Monitor operated correctly in the 24 hour period by summing counters 1 through 5 and determine that this sum is between 23.95 and 24.05.

4.c. Determine that the wind noise did not exceed the performance of the windscreen by checking that counter 7 is less than 1.00 if greater or equal to 1.00 the test must be run again; therefore go back to step 2. If less than 1.00, go to Step 5.

STEP 5

5.a. If the Monitor was mounted at the noisiest location AND future noise need not be predicted complete the data sheet and then go to step 15.

5.b. If neither of the two conditions stated in 5.a. are met, then enter the data from the Manual or Automatic Reader Data sheet into Worksheet 1 to convert the data into a usable form for the following steps.

PLOTTING DATA

STEP 6

6.a. Convert the time that all four levels were exceeded into percentage of a day by multiplying the time by 100% and then dividing this result by 24. Enter the results in Worksheet 1.

6.b. Plot the results of Step 6.a. on the graph paper contained in Figure 1, Graph Paper for Adjusting Data.

EXAMPLE FOR STEP 6 AND 7.

Example 1

In this example the following data was obtained from the reader: Time that 80 dB(A) was exceeded 0.20 hours

Time that 75 dB(A) was exceeded 1.15 hrs.

Time that 65 dB(A) was exceeded 8.65 hrs.

Time that 45 dB(A) was exceeded. 22.55 hrs.

The results of converting these data into percentage of a day are:

Percentage of day that 80 dB(A) was exceeded 0.83%

Percentage of day that 75 dB(A) was exceeded 4.79%

Percentage of day that 65 dB(A) was exceeded 36.0%

Percentage of day that 45 dB(A) was exceeded 98.1%

The data is shown plotted in the following figure.

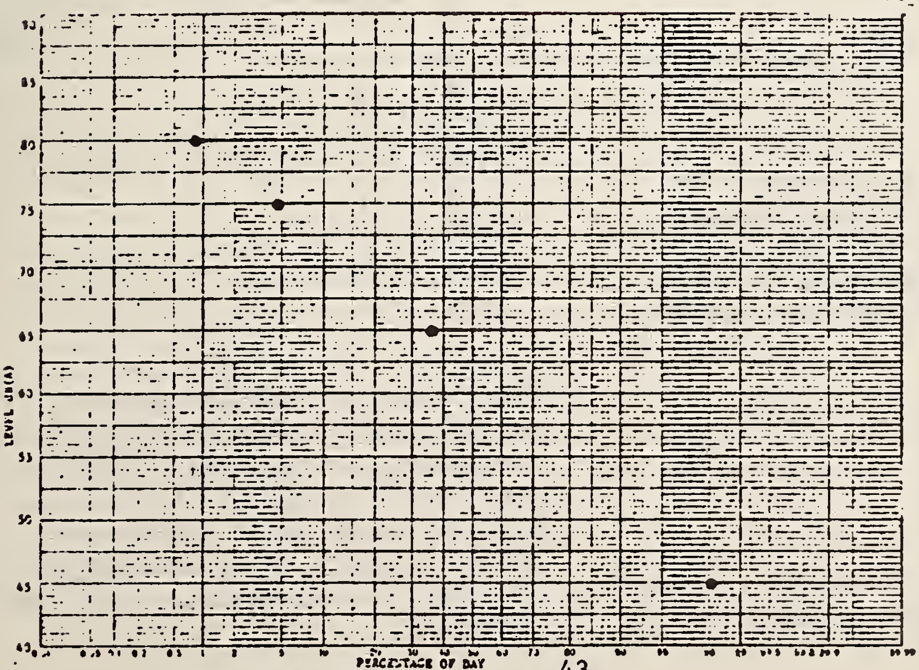


Figure 1. Graph Paper for Adjusting Data

STEP 7

Draw a smooth curve through the points plotted in Step 6.b.

ADJUSTING DATA FOR LOCATION

STEP 8

The following steps are used to adjust the data for distance when the Monitor could not be mounted at the appropriate location. If the Monitor was mounted at the appropriate location go to Step 9.

8.a. Determine the distance from the desired location to the noise source and enter this distance on Worksheet 1

8.b. Determine the distance from the actual location of the Monitor to the noise source and enter this distance on Worksheet 1.

8.c. Divide the distance found in Step 8.a. by the distance found in Step 8.b. and enter this ratio on Worksheet 1.

8.d. Find the correction in Table III for the distance ratio found in Step 8.c. Enter this correction on Worksheet 1.

8.e. If future noise must be predicted go to Step 9, if not go to Step 13.

PREDICTING FUTURE NOISE

STEP 9

Before beginning the evaluation, you should try to obtain any available information about approved plans for road changes. You will need to make adjustments for the following changes:

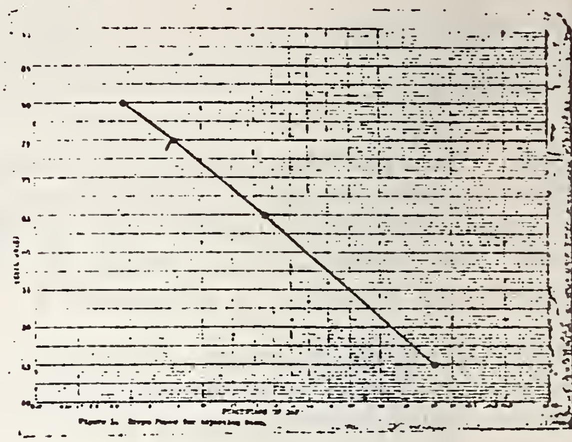
- Traffic volume
- Road gradient of 3% or more
- Traffic controls
- Mean speed
- Barriers

If the only change is in traffic volume go to Step 10. If other changes are to be made go to Step 11.

EXAMPLE FOR STEP 7.

Example 2

In the following figure the data plotted in Example 1 has a smooth curve drawn through the data points.

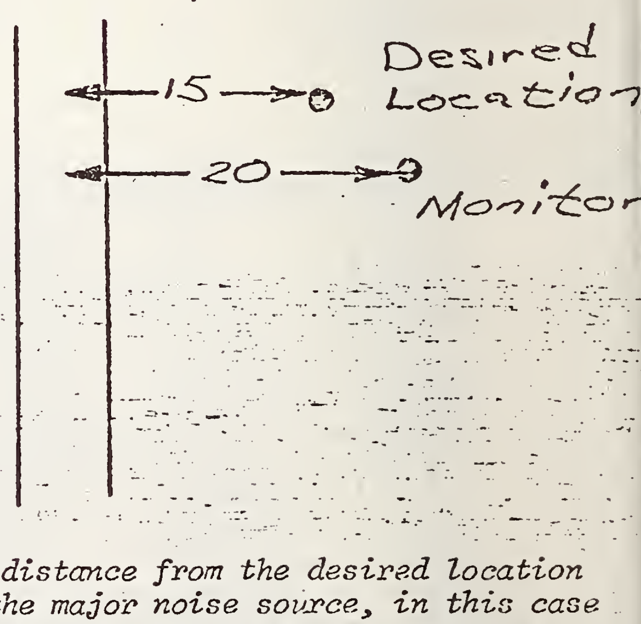


Example of curve fitted through the data points.

EXAMPLE FOR STEP 8.

Example 3

The site shown below is exposed to noise from one major road.



The distance from the desired location to the major noise source, in this case a highway, is 15 feet. The distance from the highway to the location of the Monitor is 20 feet. The ratio of the desired location to the actual location is .75. The correction from Table III is +2 dB.

Table III. Corrections for Distance. If correction is greater than +3 or less than -3, and more than one noise source can be identified, professional help may be required.

Distance Ratio	Correction dB
10	-15
8	-14
7	-13
6	-12
5	-10
4	- 9
3	- 8
2.5	- 6
2	- 4
1.6	- 3
1.4	- 2
1.25	- 1
1.2 to .85 requires no correction	
.8	+ 1
.7	+ 2
.6	3
.5	4
.4	6
.3	8
.25	9
.2	10
.15	12
.12	13
.11	14
.10	15

STEP 10

If the only change is in traffic volume use the following steps.

10.a. From the City (County) Director of Traffic obtain the peak traffic flow in both directions, combined, and enter this number on Worksheet 1.

10.b. From the same source used in Step 10.a. determine the expected traffic flow for the next 10 to 15 years, and enter this number on Worksheet 1.

10.c. Divide the flow obtained in Step 10.a. by the flow obtained in Step 10.b. and enter this ratio on Worksheet 1.

10.d. Use Table IV to find the adjustment for the ratio found in Step 10.c. Enter the correction on Worksheet 1. Then go to Step 13.

STEP 11

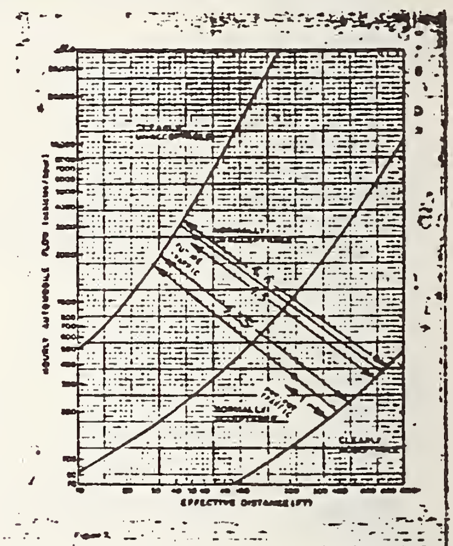
If changes other than traffic volume will occur you must use the following steps. Before doing this, complete the ROADWAYS evaluation pages 6 through 13 contained in HUD NOISE ASSESSMENT GUIDELINES for both Truck and Auto traffic, and for both present and future conditions. Upon completion of this evaluation you will have Figure 2 from the Guidelines for Hourly Automobile Flow with two reference points, one reference point for present traffic conditions and one reference for future traffic conditions. You will also have Figure 3 from the Guidelines for Hourly Truck Flow with two reference points. Do not proceed until you have completed the evaluation and have obtained the two figures and reference points.

In this example the traffic will be reduced due to a route change. The present peak hourly flow is 1000 vehicles per hour. The future peak hourly flow is estimated as 250 vehicles per hour. The ratio of present traffic flow to future traffic flow is 4, and the adjustment from Table IV is -6 dB.

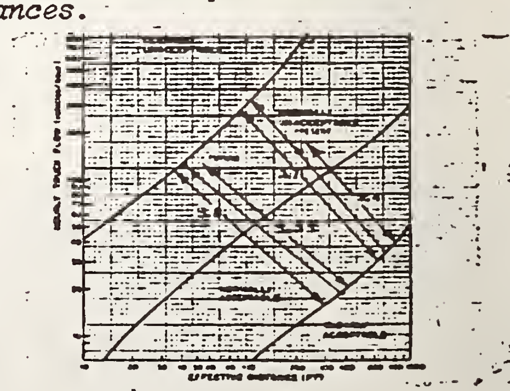
EXAMPLE FOR STEP 11 AND 12.

Example 5

In this example, traffic volume, mean speed and road gradient have been changed. The ROADWAY evaluation of the HUD NOISE ASSESSMENT GUIDELINES have been completed for change in traffic volume, mean speed and road gradient for both present and future traffic. As a result of the evaluation the following two figures have been completed.



Example of how Figure 2 of the Noise Assessment Guidelines is used to establish reference points and distances.



Example of how Figure 3 of the Noise Assessment Guidelines is used to

Table IV. Adjustment for Changes in Hourly Traffic Flow.

Ratio of Future to Present Hourly Traffic Flow	Adjustments dB
10	-10
8	- 9
7	- 8
5	- 7
4	- 6
3	- 5
2	- 3
1.5	- 2
1.25	- 1
1.2 to .7 requires no correction	
.8	1
.6	2
.5	3
.3	5
.25	6
.2	7
.15	8
.12	9
.1	10

11.a. Perform Steps 11.b. through 11.f. for the following four reference points.

- oPresent hourly automobile flow
- oFuture hourly automobile flow
- oPresent hourly truck flow
- oFuture hourly truck flow

11.b. Draw a line through the reference point such that the line is perpendicular to the upper boundry of the clearly acceptable category and the lower boundary of the clearly unacceptable category. These boundaries may have to be extended in order that the lines drawn can intersect a boundary.

11.c. Measure the length of the line drawn in Step 11.b. and enter this length in Worksheet 2.

11.d. Measure the distance from the reference point to the clearly acceptable category line and enter this distance in Worksheet 2.

The length of the two lines between categories are 4.25" and 4.6" for the present and future traffic. The distance from the clearly acceptable boundary to the reference points are 1" for the present Traffic and 4.3" for the Future Traffic. Thus, to find the weighting for present traffic we divide 1" by 4.25" and then multiply the result by 30. The result of this calculation yields 7.0. For Future Traffic the calculation yields 27.6. The difference between the two is 20.6. Performing the same calculation for trucks yields 19.5 for present traffic and 28.3 for future traffic. The difference is 9. We next compare the difference between the future truck traffic and future automobile traffic. The difference is .7 and therefore we must make a correction. From Table V. the correction is 2.5. This must be added to the correction factor with the largest weight. In this case the Future Truck has a weighting of 28.3 so we add 2.5 to 9 yielding a final correction of 11.5.

11.e. Divide the distance obtained in Step 11.d. by the length obtained in Step 11.c. and enter this weighting number in Worksheet 2.

11.f. Multiply the ratio obtained in Step 11.e. by 30 and enter the result in Worksheet 2.

11.g. Repeat Step 11.b. through 11.f. for all four reference points.

11.h. Subtract the present automobile weighting number from the future automobile weighting number obtained in Step 11.f. and enter the difference in Worksheet 2.

11.i. Subtract the present truck weighting number from the future truck weighting number and enter the difference in Worksheet 2.

STEP 12

Before the adjustment for effects of future noise can be determined the following operations must be performed.

oDetermine if the adjustment for changes in automobile and truck traffic volume need to be combined.

oDetermine which adjustment should be used.

To accomplish the above use the following steps.

12.a. Subtract the smallest correction found in Step 11.f. for future noise from the largest correction found in Step 11.f. for future noise. If the difference is greater than 6 enter the largest correction found in Step 11.h. or 11.i. in Worksheet 2 as the final correction then go to Step 13. If the difference is 6 or less enter this difference in Worksheet 2, then go to Step 12.b.

12.b. If the difference found in Step 12.a. is 6 or less find the correction in Table V and add this correction to the difference (Step 11.i.] associated with the largest number found in Step 11.f. Enter this number as the final correction in Worksheet 2.

Table V. Adjustments when Differences are Less than 6.

Difference	Adjustment dB
0	3
1	2.5
2	2
4	1.5
6	1

STEP 13

This step combines the adjustment for distance and the correction for future traffic changes. If only adjustments for distance were made, or only future traffic changes were made, enter the results of Step 8.d. for distance adjustment or the results of Step 10.c., 12.a. or 12.b. for traffic changes as the shift factor in Worksheet 3 and go to Step 14.

13.a. If both adjustments for distance and prediction for traffic changes are made add the results of Step 8.d. and Step 10.c., 12.a., or 12.b. and enter this sum as the shift factor in Worksheet 3. In performing this addition you are cautioned to observe the signs on the two numbers.

STEP 14

The curve drawn in Step 7 should be shift by the shift factor found in Step 13. Shift the curve up for a positive correction and down for a negative correction.

FINAL RESULTS

STEP 15

If no adjustments were made to the data check the category on Worksheet 3. Use the levels indicated in Table I for determining acceptability of the site. If adjustments were made use the following steps.

15.a. Find the percentage of time that 80, 75, 65 and 45 dB(A) was exceeded. Note that the projected curve will have to be extended to find the percentage of a day corresponding to 1390.2. Policy circular 1390.2 is given in Table VI in terms of percentage of a day.

15.b. Use the levels indicated in Table I for determining acceptability of the site.

Example 6

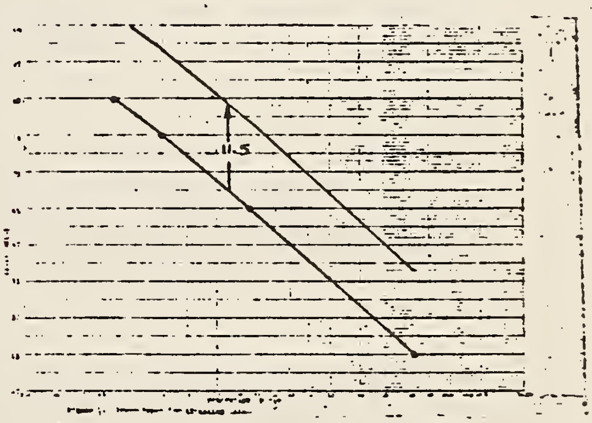
In this we will develop shift factors for some of the examples. Suppose that the Monitor was not mounted at the desired location but was mounted as described in Example 3. Additionally, traffic volume will change as described in Example 4. The corrections for these two examples were +2 and -6 dB. Thus, the shift factor is -4 dB.

Suppose that the Monitor was mounted at the desired location and the traffic conditions, described in Example 5, were used. Then the shift factor is 11.5.

EXAMPLE FOR STEP 14.

Example 7

In this example we will use the last shift factor found in Example 6. Recall that this shift factor was 11.5. The shifted data is shown in the following Figure.



Example of shifted data.

Notice that 80 dB(A) is exceeded 21% of 24 hours. This is greater than 4.17%, which is 60 minutes. Thus, the site is unacceptable. Additionally, 75 dB(A) is exceeded 46%, which is greater than 33% which is 8 hours, which would make the site unacceptable.

TABLE VI

EXTERNAL NOISE EXPOSURES FOR NEW RESIDENTIAL CONSTRUCTION

IN A-WEIGHTED SOUND PRESSURE LEVELS

UNACCEPTABLE

Exceeds 80 dB(A) 4.2% of a day
Exceeds 75 dB(A) 33% of a day

DISCRETIONARY -- NORMALLY UNACCEPTABLE

Exceeds 65 dB(A) 33% of a day
Loud repetitive sounds on site

DISCRETIONARY -- NORMALLY ACCEPTABLE

Does not exceed 65 dB(A) more than 33% of a day

ACCEPTABLE

Does not exceed 45 dB(A) more than 2.1% of a day

9. APPENDIX D

HUD NOISE MEASUREMENT SYSTEM USE LOG

Introduction

The purpose of this Log is to help improve the HUD Noise Measurement System (NMS). Through the use of this Log, improvement can be made to both the written instructions and the hardware. The LOG should be returned to NBS each time the NMS is used. Please return it to:

D. S. Blomquist
National Bureau of Standards
Applied Acoustics Section
Sound Building, Rm. A149
Washington, D. C. 20234
301-921-3381

Office ______________________________

User ______________________________

User's Telephone Number ______________

Serial Number ______________

Date Used ______________

1. Was appropriate location for mounting system difficult to find? Briefly describe any difficulty on the back of this sheet.

   Yes _____ No _____

2. Approximately how long did it take to find the mounting location. ________

3. Briefly describe any problems in obtaining permission to mount system. (on the back of this sheet)

4. Where was system mounted?

   _____utility standard _____stake and pole ____other

5. Approximate mounted height of system in feet ___________

6. Who performed mounting? ____HUD Personnel _____Utility Company

   ____City or State Personnel ____Other

7. What was used for mounting? ____Ladder ____Other

8. If you had any problems mounting system please describe them on back of this sheet.

   Yes ____ No____

9. Approximately how long did it take to mount the system. _______________

10. Where was calibration performed? ____Office ____Measurement site.

If at measurement site, could Monitor indicator lights be seen?

Yes ____ Yes, with difficulty ____

11. From the local newspaper obtain the maximum and minimum temperatures for the measurement period.

_______Maximum temperature _______Minimum temperature

12. What were weather conditions? ____Rain ____Sleet ____Snow ____Clear

13. Who performed demounting? ____Hud Personnel ____Utility Company

____City or State Personnel ____Other

14. If Dummy Monitor was mounted before Monitor was mounted, please answer the following:

a. Period of time dummy was mounted (check):

Less than 24 hrs ____

24 Hrs ____

If more than 24 hrs, how long ______________

b. Height above ground (ft) __________

c. Was Monitor mounted at same height above ground as dummy?

Yes ____ No, what was difference _______________

d. Was there any visible damage to dummy. No ____
If yes, describe on back of sheet.

15. Were local police authorities notified? Yes____ No ____

16. Was there any evidence of vandalism? If yes, please describe nature of damage and how you think this damage might have occurred (on back of this sheet).

Yes ____ No ____

17. If system failed to calibrate the second time, or the data did not sum between 23.95 and 24.05 (MM printed out on Automatic Reader), please complete the following questions.

a. Is there any water condensation in the Monitor case? Yes____ No____

b. Were the Monitor batteries charged before use? Yes____ No____

PROCEED NO FURTHER, GO TO QUESTION **21.**

18. Please enter data here.

Time	Level
____________	Greater than 80 dB(A)
____________	Greater than 75 dB(A)
____________	Greater than 65 dB(A)
____________	Greater than 45 dB(A)
____________	Performance of windscreen was exceeded
____________	Number of events greater than 80 dB(A)

If the time that the performance of windscreen was exceeded was greater than 1 hour DO NOT PROCEED, GO TO QUESTION 21.

If the number of events greater than 80 dB(A) was more than 10, can you identify the source, such as the site is: subject to aircraft operations, less than 3000 feet from railroad operations, near a manufacturing operation, near a construction project, etc. (please describe on the back of this sheet).

The following questions concern adjustments to the data. If no adjustments were made for distance or future traffic flow do not answer questions 19 and 20.

19. Was data corrected for different location? Yes____ No____

If yes, (a) how much was the correction? _____dB

(b) was there more than one source identified? How many? _____

20. Was future noise exposure predicted from data? Yes____ No____

If yes, please answer following:

a. What was correction for auto traffic? _____dB?

b. What was correction for truck traffic? _____dB?

c. What was combined correction? _____dB?

21. Explain any other difficulties; for example, more instructions are needed on mounting windsensor, banding material is difficult to use in cold weather, shock cord is not necessary, adjustment of data for distance is difficult, calculator is required for data calculations, etc.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

In 1973, the Office of Noise Abatement Research, Department of Housing and Urban Development, contracted with the Applied Acoustics Section of the National Bureau of Standards to develop a noise exposure measurement system. This system was subsequently developed, seventeen prototype units were procured, and a full-scale laboratory and field evaluation of the units were conducted. This report discusses the results of the evaluation, as well as the rationale behind and recommendations for changes and revisions to the HUD noise measurement system specifications.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Acoustics; community noise; environmental impact; noise; noise exposure measurement system; sound.

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