SOME PROPULSION SYSTEM NOISE DATA HANDLING CONVENTIONS AND COMPUTER PROGRAMS USED AT THE LEWIS RESEARCH CENTER

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Methods of handling one-third-octave band noise data originating from the outdoor full-scale fan noise facility and the engine acoustic facility at the Lewis Research Center are presented. Procedures for standardizing, retrieving, extrapolating, and reporting these data are explained. Computer programs are given which are used to accomplish these and other noise data analysis tasks. This information is useful as background for interpretation of data from these facilities appearing in NASA reports and can aid data exchange by promoting standardization.
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SUMMARY

Methods of handling one-third-octave band noise data originating from the outdoor full-scale fan noise facility and the engine acoustic facility at the Lewis Research Center are presented. Procedures for standardizing, retrieving, extrapolating, and reporting these data are explained. Computer programs are given which are used to accomplish these and other noise data analysis tasks. This information is useful as background for interpretation of data from these facilities appearing in NASA reports and can aid data exchange by promoting standardization.

INTRODUCTION

The last several years have seen a rapid rise in the level of research relating to the noise of aircraft propulsion systems. Various companies, universities, and government agencies have been contributing to an increasing body of technical data. A significant volume among these data is comprised of the results of one-third-octave band analyses of the noise signatures of propulsion systems or components either from full-scale hardware or from models. Thorough analyses of these data are essential to the development of an understanding of the mechanisms of noise generation and, at the very least, to the development of noise prediction methods which are important to the proper evolution of quiet propulsion systems. Researchers using the full-scale fan and the engine acoustic facilities at the Lewis Research Center are among those generating and manipulating large volumes of one-third-octave band noise data. Several years ago, the generation of such quantities of data was anticipated, and data handling practices were established to facilitate the manipulation and analyses of these data at the user level. These practices center around a collection of computer programs which are used to process the data and
a philosophy of data standardization and storage. Extensive use of these methods has demonstrated their worth. Interest shown by others outside of NASA has indicated that these practices may be generally useful, particularly with regard to standardization and facilitation of more direct data exchange especially in computer-compatible form. In addition, considerable data from the full-scale fan facility and the engine acoustic facility are being published which are handled by the methods discussed herein. Typical of such publications is reference 1.

This report therefore sets forth the practices that are followed at the Lewis Research Center with regard to standardizing, retrieving, extrapolating, and reporting noise data from these facilities. The adjustments made to the data for standardization purposes and other practices are explained, and a collection of computer programs is given. It is hoped that these practices, which have proven useful at Lewis over the past several years, will be of use to others engaged in propulsion system noise research.

**DATA ACQUISITION AND DOCUMENTATION**

This section includes information on the manner in which collections of data are identified and manipulated. To assist in presenting this information, a block diagram is presented in figure 1. This diagram gives an overview of the major elements which are involved in the data handling system. It is pertinent to much of the discussion which follows.

**Data Standardization**

**Measured array.** - The kind of data under consideration in the context of this report are the results of one-third-octave band spectral analyses of the far-field radiated noise from axisymmetric sources. In general, measurements are made about the source at equal angle increments. Irrespective of the manner of testing, and whether one run is made or the data from a few runs are averaged, the net result is an array of data comprised of sound pressure levels in one-third-octave bands for a number of angles. This array is referred to herein as the "Measured Array" and is the starting point for all further discussion. Effects of instrumentation frequency response are presumed to be removed.

A Measured Array is identified with an operating point of the source and consists of an NF×NM matrix of sound pressure levels, where NF is the number of frequency bands and NM is the number of microphones or angles. The usual range of frequencies is from 50 to 20 000 hertz. Microphones commonly are employed in 10° increments over most of a 180° arc.
Site effects. - The Measured Array, whether obtained indoors or out, in general possesses measurement anomalies which are attributable to the site and also to the ambient air conditions. Site-related anomalies such as ground plane reflections are the subject of continuing interest. A discussion of them exceeds the scope of this report. For full-scale fan and engine facilities, data are not adjusted routinely for site effects, but their inclusion is always implied, and it is intended that they be given consideration as the use of the data dictates.

Excess atmospheric attenuation. - Data are filed for use essentially as obtained except for standardization for atmospheric effects. Ambient air, of course, is known to cause excess sound attenuation (over and above inverse square law attenuation) which is a function of frequency, temperature, and humidity. Data to evaluate this effect are contained in reference 2.

Reference 2 was created in a framework of jet noise. And in addition to the air attenuation data contained therein, which are essentially continuous functions of frequency, guidelines are presented for applying those data to one-third-octave band spectra which are discontinuous. The guidelines specify the use of the band center frequency for determining the air attenuation for one-third-octave bands to 4000 hertz and for using the band lower limiting frequency above 4000 hertz. This procedure is biased for jet noise, which has a characteristic fall-off at high frequency. The theoretically correct attenuation which should be used must be the result of an integration which accounts for the combination of spectral and attenuation variations over a frequency band. When both these characteristics are relatively flat, the use of the attenuation at the band center frequency is appropriate. But when large changes occur in either characteristic over a frequency band, the band center frequency is not an adequate parameter. For jet noise, use of the band lower limiting frequency is satisfactory; but this is not true in general. The manner of determining atmospheric correction which is discussed in the next section uses the data of reference 2, but does so by an integration process over each frequency band. This integration cannot be done precisely with knowledge only of the one-third-octave band spectrum, but the spectrum shape is approximated conceptually by assuming a straight-line connection between sound pressure levels in adjacent frequency bands on a spectral plot with a logarithmic frequency scale.

Referred array. - The only adjustments which the Measured Array undergoes prior to use at the working level are removal of the effect of atmospheric absorption for the conditions that prevailed at the test site and adjustment to a standard radius for any microphones not on that standard radius for the test. The atmospheric attenuation for the test ambient temperature and relative humidity for each one-third-octave band spectrum is calculated as noted in the previous section. These results are added to the measured data for the appropriate propagation distance. And inverse square adjustments are made where necessary (fig. 1). The results are sound pressure levels that would exist at the microphones on a constant radius if the atmosphere were completely
nonattenuating. Therefore, these results are never to be expected in reality. It is from these data, however, that source acoustic power and directivity properties must be calculated. The array so adjusted is termed the "Referred Array," implying that it possesses acoustic properties that refer back to the source and are uninfluenced by the propagation properties of the medium except for inverse square attenuation.

It follows that a Referred Array may be extrapolated to any distance by using the inverse square law while preserving its intrinsic acoustic power and directivity properties. Conversely, when acoustic power and directivity properties of a source are known, a Referred Array can be constructed for any distance from the source (fig. 1), and by incorporating the effects of atmospheric absorption, far-field sound pressure levels may be constructed.

Working Data

From the Referred Array, the essential properties of the source acoustic emission are calculated. These properties consist of overall power level, normalized power spectrum, and directivity index for each frequency band. These data are useful directly in the characterization of the source acoustic emission and in understanding noise generating mechanisms. Further, they are independent of the original measurement distances.

It is these data, retained on punched cards, that constitute the heart of the retrieval system. The data in this form are called "Working Data."

These noise data so decomposed into fundamental emission properties can contribute to understanding of noise generating mechanisms through the development of improved prediction techniques, for which they are suited particularly well. Each of the three basic elements - power level, normalized spectrum, and directivity index - can be examined separately and independently. Power level is a single variable which, in general, can be expected to correlate simply with size, thrust, or mechanical power. Quite independently, normalized power spectrum (which embodies only the shape and frequency scale of the spectral emission) may be expected to correlate with such things as mechanical design and characteristic speed. And finally, directivity index may be isolated and separately investigated insofar as it pertains to questions of theoretical acoustic propagation, duct terminations, flow refraction, and so forth. The extent of understanding any one of these emission properties is not dependent necessarily on the understanding of any other.

This general independence of the emission properties is also particularly useful to meet short-term needs for noise predictions. State-of-the-art noise prediction methods rely heavily on an empirical data base. Working Data facilitate such predictions by permitting selective use of the appropriate emission properties from a variety of sources.
Although Working Data, at a glance, do not consist of familiar sound pressure levels, this is no obstacle to users desirous of data in that form. With a computer-oriented system such as this, it is a simple task to assemble the Working Data into a referred sound pressure level array. This array in turn can be extrapolated for any far-field conditions (fig. 1).

For the foregoing reasons, all noise data are decomposed into the source fundamental emission properties, punched into cards, and filed for use in this form at the working level. Appendix A contains a sample listing of Working Data, with complete explanation of the format. The retention of data in this form, in conjunction with a family of computer programs which are given herein, facilitates rapid dissemination and efficient utilization of the data. The manner in which Working Data are computed from the Referred Array is discussed in the next sections.

**Acoustic power.** - A general sound source emits acoustic energy radially to the far-field and nonuniformly with direction. The acoustic power emitted by the source can be obtained by integrating the far-field sound intensity over an enclosing surface. It is here presumed that the source and its associated sound field are axisymmetric so that the intensity field is a function of only two coordinates, radial distance \( r \) from the source and azimuth angle \( \theta \) from the source axis. For far-field noise radiation, discounting excess atmospheric attenuation, the sound intensity varies inversely as the square of the distance from the source so that the functional dependence on \( r \) is known. Further, the sound intensity \( I \) is related to the rms acoustic pressure \( P \), which is the usual measured quantity, according to

\[
I = \frac{P^2}{\rho c}
\]

where \( \rho c \) is the characteristic impedance of the propagating medium. Under such conditions, the rms sound pressure may be determined at a constant radius \( R \), from which the acoustic power \( W \) is obtained according to

\[
W = \frac{1}{\rho c} \int_{0}^{\pi} P^2(\theta) \, dA
\]

where

\[
dA = 2\pi R^2 \, d\theta
\]

is the elemental annulus area on an enclosing sphere.
In practice, a function \( P(\theta) \) is not usually available, but rather, discrete values \( P_i^2 \) \((i = 0, 1, \ldots, n)\) are known from measurements corresponding to values of \( \theta \). Under these conditions, equation (2) must be approximated as a finite sum

\[
W = \frac{1}{\rho c} \sum_{i=0}^{n} P_i^2 \Delta A_i
\]

where the \( \Delta A_i \) are contiguous finite incremental areas on which the corresponding \( P_i^2 \) are presumed constant.

If the \( \theta \) are taken to be equally spaced by an angle increment \( \Delta \theta \), which therefore becomes also the arc width of any elemental area \( \Delta A_i \), and if the \( \theta \) are written as \( i \Delta \theta \), the incremental areas can be expressed as

\[
\Delta A_i = 2\pi R^2 \sin \left( \frac{\Delta \theta}{2} \right) \tan \left( \frac{\Delta \theta}{4} \right) \quad i \Delta \theta = 0, \pi
\]

\[
\Delta A_i = 4\pi R^2 \sin \left( \frac{\Delta \theta}{2} \right) \sin(i \Delta \theta) \quad 0 < i \Delta \theta < \pi
\]

The geometry of the arrangement is shown in figure 2. When the azimuth angle \( i \Delta \theta \) corresponds with a polar area on the sphere, equation (5) applies; otherwise equation (6) applies.

Combining equations (4) to (6) results in

\[
W = \frac{4\pi R^2}{\rho c} \sin \left( \frac{\Delta \theta}{2} \right) \left[ P_0^2 \tan \left( \frac{\Delta \theta}{4} \right) + \sum_{i=1}^{n-1} P_i^2 \sin(i \Delta \theta) + \frac{P_n^2}{2} \tan \left( \frac{\Delta \theta}{4} \right) \right]
\]

where the subscripts \( 0 \) and \( n \) denote the polar areas.

Equation (7) is basically that used for acoustic power calculation as discussed herein. However, as written, it applies specifically to radiation in the absence of a ground plane since a summation is taken with fully circular annuli. Most practical propulsion system noise measurements are taken in an environment with a reflecting ground plane, and the problems it presents must be considered.

In actual fact, the directly radiated instantaneous sound pressure and that reflected from the ground plane sum algebraically at the microphone. The resultant effects
depend on the geometry of the problem, the frequency of the radiation, the phase shifts and attenuations in the reflection process, and the bandwidth of the analysis technique, among other things. For one-third-octave band analysis, there usually result band-dominant signal reinforcement and cancellation effects in the low-frequency end of the spectrum which are highly dependent on the test arrangement. However, for any arrangement, many signal reinforcements and cancellations occur in any given one-third-octave band at the high-frequency end of the spectrum which, for hard reflecting surfaces, result in a theoretical doubling of intensity there. Since Lewis test sites use hard pavement reflecting surfaces for purposes of maintaining surface constancy, the doubling of intensity at high frequencies is taken to be the prevailing phenomenon. The acoustic power calculation therefore proceeds on the assumption that the acoustic intensities determined to exist in the presence of the ground plane are double what they would be in its absence. Thus, the intensities are halved for all frequency bands and summed over the entire sphere according to equation (7). No attempts are made to correct the data for ground interference effects at low frequencies.

The use of Working Data offers a convenient means of transmitting data to other users. It must be cautioned, however, that if the Referred Array is to be precisely reconstructed, the exact power calculation method which was used to generate the Working Data must be available and inverted; otherwise differences will result. The computer subroutine to compute acoustic power as given by equation (7) and the preceding discussion is called POWER and is given in appendix B. Where sound pressure level data are not available (e.g., near the source axis, where jet flow would impinge on the microphones), the associated areas are excluded from the summation process of the power calculation.

Directivity index. - Directivity index is a normalizing way of characterizing the directional property of far-field acoustic emission. It is defined as the difference, in decibels, between the existing sound pressure level at a point and the sound pressure level that would exist at the same point from a simple source emitting the same acoustic power. Directivity index is a function of direction only; and for an axisymmetric source, therefore, it is a function of azimuth angle $\theta$. For discrete values of $\theta_i$ it is defined by

$$DI_{\theta_i} = SPL_{\theta_i} - SPL_{AV}$$

(8)

where $SPL_{\theta_i}$ denotes the existing sound pressure levels and $SPL_{AV}$ represents the simple-source sound pressure level. The simple-source sound pressure level can be shown to be exactly the area-weighted average sound pressure level of the existing $SPL_{\theta_i}$. It is computed according to
\begin{equation}
\text{SPL}_{AV} = 10 \log_{10} \left( \sum_{i=0}^{n} \frac{\text{SPL}_{\theta_i}}{10^{10} \cdot \Delta A_i} \right)
\end{equation}

where the $\Delta A_i$ are given by equations (5) and (6).

A subroutine AVSLR for computing the area-weighted sound pressure level is given in appendix B. As in the acoustic power calculation, where no data exist for angles at or near the axis, such angles are omitted from the summation process.

**Extrapolation**

Often, for practical purposes, the detailed properties of the source radiation such as directivity index are not needed, but rather the far-field sound pressure levels that result when the data are extrapolated to various distances are necessary. Usually, data of this kind are reported in the literature. To generate such data, it is only necessary to assemble a Referred Array from the Working Data and extrapolate it to the desired distances by using the inverse square law and excess atmospheric attenuation for the conditions desired, usually standard day (fig. 1). Other effects such as ground reflections or extra ground attenuation are given consideration by some investigators in extrapolation calculations. However, as in the case of measurement anomalies, other extrapolation phenomena are the subject of continuing research and exceed the scope of the discussion here. These phenomena are neglected in ordinary data extrapolations for reporting purposes or for data retention at the working level. Such a practice avoids the need for qualifying the data. Further, it permits any user to quickly deduce from the data the referred arrays which accurately reflect the original data which were measured and which he may modify to suit his needs considering test site or extrapolation anomalies.
COMPUTER PROGRAMS

Working Data Generation

The key to the efficient retrieval and use of noise data at the working level lies in maintaining a punched card file of Working Data sets and a family of programs and subroutines for manipulating those data. There exists, of course, archival storage of the raw measured data. But utilization of these data directly requires extensive computer interaction and program handling, particularly since the data to be so retrieved and processed consist of repeat runs which must be averaged, corrected for measurement instrumentation response when necessary, and adjusted to standard-day conditions. The use of Working Data, which is one level removed from the archival data, permits rapid data access by persons not necessarily skilled in computer usage.

The effort avoided by the routine use of Working Data in place of archival data is replaced by the one-time use of a computer program which generates the Working Data and which also generates other useful data listings. This program is called WODAG (for Working Data Generation), and an outline of the calculations it performs and the listings it generates are discussed next. WODAG is a subroutine whose principal input is a Measured Array. A main program which must provide suitable Measured Arrays and call the subroutine WODAG is the responsibility of the reader. The complete codes of the subroutine WODAG and of the subroutines which it calls are given in appendix B.

Listings. - A sample listing of the printed output generated by WODAG is presented in table I. Each page of output is somewhat self-explanatory, but they are reviewed briefly here. A summary of the pages by title is as follows:

(1) Measured Array
(2) Test-day excess atmospheric attenuation
(3) Referred Array
(4) Acoustic power computations
(5) Normalized power spectrum (graph)
(6) Directivity index
(7) Atmospheric attenuation
(8) Standard-day data excess atmospheric attenuation
(9) Standard-day data
(10 and following) Sideline extrapolated data

The Measured Array has been discussed. It is identifiable with a particular operating condition of the source and represents the actual measured data (or an average of data) from the test site with instrumentation frequency response characteristics removed. Variable microphone radii are permitted and appear in the listing. Atmospheric
conditions for the test are also listed. All test data as printed are adjusted to a constant radius for review purposes by using inverse square law only. For all subsequent calculations the proper atmospheric absorptions and distances are accurately accounted for.

The test-day excess atmospheric attenuation table gives the actual adjustments, based on test temperature, relative humidity, and actual measurement distances, used to generate the Referred Array.

The Referred Array is tabulated for a selected radius and, in addition, overall levels at each angle are listed. No perceived noise levels are presented since the referred data represent a condition that cannot be observed.

Results of acoustic power calculations which are listed include overall acoustic power, acoustic power spectrum, and normalized power spectrum. The normalized spectrum is obtained by subtracting the maximum band power level from the power spectrum. In addition, the simple-source sound pressure levels are listed. These are referred sound pressure levels created by a nondirectional source emitting the same acoustic power as the real source. Simple-source sound pressure levels (average sound pressure levels given by eq. (9)) are used to calculate directivity index according to equation (8). Directivity index is listed in a separate table for the sound pressure levels in each frequency band and for the overall levels.

Tables of standard-day excess atmospheric attenuation are given, the first of which is the attenuation per thousand feet of propagation distance. This table is computed from the Referred Array as discussed in the section Excess atmospheric attenuation and is used for all subsequent extrapolations. A second atmospheric attenuation table is given which lists the exact adjustments that were made to the referred array to generate the standard-day array for the same radius. The atmospheric adjustments vary from angle to angle because the spectral shapes are accounted for as previously discussed.

Subsequent tables provide data extrapolated to selected sidelines. The first of these sidelines is always at the same distance as the radius used for the standard-day data.

Punched cards. - In addition to the foregoing printed output, WODAG also punches data into cards in the Working Data format as discussed previously. These cards are intended for routine use at the user working level in conjunction with a family of programs and subroutines which are discussed next.

General Programs and Subroutines

A principal reason for the use of Working Data is to permit convenient access to data in all its detail. Since the card data format is standardized and contains control information, one set may be read into computer storage with a simple call to a subroutine. Similar calls to other subroutines will generate Referred Arrays, do extrapo-
lations, generate perceived noise levels, and so forth. This modular approach to pro-
gramming for purposes of handling the data frees the user-programmer from concern
over routine data handling tasks. The use of other main programs permits nonprogram-
mers also to conveniently access, extrapolate, and analyze data starting with Working
Data (fig. 1). A number of programs used for these various purposes are discussed in
this section.

Source codes written in FORTRAN IV for all the programs which are discussed in
this report and other utility subroutines necessary to support them are given in appen-
dix B alphabetically by name. All program listings contain information which makes
them self-explanatory. Many of them have a general use to those engaged in noise work.
Others, described as "utility" routines, are used solely to perform very specific and
mundane calling program tasks.

Following is an alphabetical summary of all the programs in appendix B with de-
scriptions of their functions:

<table>
<thead>
<tr>
<th>Program name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANGLE</td>
<td>(Utility)</td>
</tr>
<tr>
<td>APNDB</td>
<td>(Utility)</td>
</tr>
</tbody>
</table>
| ASMBL        | Assembles one set of Working Data already in storage into a
              | Referred Array. |
| ATMAT        | Computes excess atmospheric attenuation in decibels for any temper-
              | ature, relative humidity, frequency, and distance. Uses empirical
              | curve-fits of data contained in reference 2. |
| AVLSR        | Computes simple-source sound pressure level (area-weighted aver-
              | age sound pressure level) from directional data on an arc. Results
              | used for directivity index calculations. |
| BASPAT       | Computes excess atmospheric attenuation for all bands of a
              | fractional octave band spectrum considering spectrum shape. Also
              | extrapolates spectrum to a new distance, accounting for inverse
              | square and atmospheric attenuation. |
| DADIFF       | Used for thorough comparison of noise characteristics of two sources.
              | Computes the differences between two sets of data. Differences in-
              | clude acoustic power (including front/rear power split arbitrarily
              | divided at 90° to the source axis), Referred Arrays, and perceived
              | noise levels and tone-corrected perceived noise levels for standard-
<pre><code>          | day data extrapolated to selected sidelines. |
</code></pre>
<p>| DBSUM        | (Utility)   |</p>
<table>
<thead>
<tr>
<th>Program name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FARDTA</td>
<td>Extrapolates a Referred Array to any far-field radius or sideline, accounting for inverse square and excess atmospheric attenuation.</td>
</tr>
<tr>
<td>GRAPH</td>
<td>(Utility)</td>
</tr>
<tr>
<td>LIST</td>
<td>Reads and assembles sets of Working Data and prepares printed output of the basic data and standard-day arc extrapolations including optional extrapolations to selected sideline distances. (Output identical with that of WODAG commencing with Referred Array.)</td>
</tr>
<tr>
<td>OASPL</td>
<td>(Utility)</td>
</tr>
<tr>
<td>PNDB</td>
<td>Computes perceived noise level in PNdB in accordance with reference 3.</td>
</tr>
<tr>
<td>PNLT</td>
<td>Computes tone-corrected perceived noise level (PNLT) for a one-third-octave band sound spectrum in accordance with reference 4. Also computes perceived noise level.</td>
</tr>
<tr>
<td>POWER</td>
<td>Computes total acoustic power by incremental area summation for a set of angles and referred sound pressure levels on an arc. Perfectly reflective ground plane assumed.</td>
</tr>
<tr>
<td>SIDLAT</td>
<td>(Utility)</td>
</tr>
<tr>
<td>TABLE</td>
<td>Prepares a compact one-page table of data in a format suitable for reporting purposes. The output includes standard-day extrapolated data on an arc, total acoustic power, power spectrum, simple-source sound pressure levels (which, with nominal band atmospheric attenuation, permit quick evaluation of directivity index), and optional sideline perceived noise levels.</td>
</tr>
<tr>
<td>TBLOP</td>
<td>(Utility)</td>
</tr>
<tr>
<td>TITLE</td>
<td>(Utility)</td>
</tr>
<tr>
<td>TITLE 2</td>
<td>(Utility)</td>
</tr>
<tr>
<td>WDATA</td>
<td>Reads one set of Working Data from cards into storage.</td>
</tr>
<tr>
<td>WODAG</td>
<td>As discussed herein, standardizes measured data, prepares data listings, and punches Working Data.</td>
</tr>
</tbody>
</table>

Sample output from WODAG, TABLE, and DADIFF are given herein tables I, II, and III, respectively.
CONCLUDING REMARKS

Methods of data handling and computer programs have been presented which have proven useful for a wide variety of tasks with data from the full-scale fan and engine acoustic test facilities at the Lewis Research Center. These methods center on the use of immediately accessible data punched into cards as standard-format Working Data which include power level, normalized power spectrum, and directivity index. Working Data are useful in understanding mechanisms of generation, developing prediction methods, and executing empirical predictions. Working Data and the associated programs also simplify the problems of user-programmers and nonprogrammers in the tasks of accessing and manipulating the data and increase the productivity and quality of data analyses. It is hoped that these advantages, in addition to the information presented herein, will be of use to others and may lead ultimately to improvements in information exchange.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, October 12, 1973,
APPENDIX A

WORKING DATA CARD FORMAT

Working Data are normalized acoustic data arranged in a standard format and used for card input for a variety of data analysis programs. A single set of data is complete and self-contained and represents the acoustic emission properties for one operating condition of a sound source.

The data are arranged in five blocks. Block 1 consists always of four cards of identifying information. This information is not manipulated in any way but is read alphanumerically. Any or all of the four cards may be blank, and all 80 card columns may be used.

Block 2 consists of a single card providing control data and identification of the particular operating conditions for this data set. The data, location, and format on the block 2 card are as follows:

<table>
<thead>
<tr>
<th>Card column</th>
<th>1</th>
<th>5</th>
<th>13</th>
<th>21</th>
<th>24</th>
<th>27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>NCONF</td>
<td>RPM</td>
<td>PCS</td>
<td>NF</td>
<td>NM</td>
<td>NB</td>
</tr>
<tr>
<td>FORTRAN format</td>
<td>I4</td>
<td>F8.1</td>
<td>F8.1</td>
<td>I3</td>
<td>I3</td>
<td>I3</td>
</tr>
</tbody>
</table>

- NCONF: configuration number
- RPM: speed, rpm
- PCS: percent speed
- NF: number of fractional-octave band filters employed, up to 27
- NM: number of equally spaced angles for the data array, up to 19
- NB: 1/NB-octave frequency bands

Obviously, where NCONF, RPM, and PCS as defined are inappropriate for the sound source, other operating variables may be used.

Block 3 consists of one, two, or three cards, depending on the value of NF. The first card is arranged in the following way:

<table>
<thead>
<tr>
<th>Card column</th>
<th>1</th>
<th>7</th>
<th>13</th>
<th>19</th>
<th>...</th>
<th>67</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable name</td>
<td>PWL</td>
<td>SUMN</td>
<td>PSM(1)</td>
<td>PSM(2)</td>
<td>...</td>
<td>PSM(10)</td>
</tr>
<tr>
<td>FORTRAN format</td>
<td>F6.1</td>
<td>F6.1</td>
<td>F6.1</td>
<td>F6.1</td>
<td>...</td>
<td>F6.1</td>
</tr>
</tbody>
</table>
PWL total acoustic power level, dB referenced to $10^{-13}$ W
SUMN antilogarithmic sum in decibels of the normalized power spectrum
PSM(I) normalized power spectrum, the power spectrum from which has been subtracted the maximum band level

Cards 2 and 3 of block 3, when they exist, are arranged as follows:

Card column
1 13 19 ... 67

Variable
(Blank) PSM(11) PSM(12) ... PSM(20)

FORTRAN format 12x F6.1 F6.1 ... F6.1

Card column
1 13 19 ... 49

Variable
(Blank) PSM(21) PSM(22) ... PSM(27)

FORTRAN format 12x F6.1 F6.1 ... F6.1

The index of PSM(I) terminates with the value of NF.

Block 4 consists of at least one card having the increment angle DT followed by the actual microphone angles AI(J), continuing on to the first column of a second card if necessary. The format is 12F6.1/8F6.1. Not counting the increment angle, the number of angles agrees with the value of NM.

Block 5 cards contain the directivity index DI(I, J) for each frequency band denoted by both a band number I and the band center frequency NFIL(I). The subscript J denotes angle. Block 5 consists of NF sets of one or two cards each. The card formats for the Ith set are

Card column
1 7 13 19 ... 67

Variable name I NFIL(I) DI(I, 1) DI(I, 2) ... DI(I, 10)

FORTRAN format I6 I6 F6.1 F6.1 ... F6.1

Card column
1 13 ... 61 ...

Variable name (Blank) DI(I, 11) ... DI(I, 19) ...

FORTRAN format 12x F6.1 ... F6.1 ...
The index $J$ of $D(I, J)$ terminates with the value of $NM$.

A listing of a typical set of working data is given in table IV. The maximum number of cards in a set is 64.
APPENDIX B

COMPUTER PROGRAMS

SUBROUTINE ANGLE (AI, NM)

C SUBROUTINE ANGLE (AI, NM)
C /ANGLE - ANGLE OUTPUT/
C ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
C * UTILITY ROUTINE TO OUTPUT ANGLE ARRAY.
C * AI ANGLES
C * NM NUMBER OF ANGLES
C ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
DIMENSION AI(19)
WRITE (6,1) (AI(I), I=1,NM)
1 FORMAT (10X,5HANGLE,19F6.0)
WRITE (6,2)
2 FORMAT (/)
RETURN
END

SUBROUTINE APNDB (A,NB,NM,PL)

C SUBROUTINE APNDB (A,NB,NM,PL)
C /APNDB - ARRAY PNDB/
C ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
C * UTILITY ROUTINE TO COMPUTE PNDB FOR ALL ANGLES OF A DATA ARRAY.
C * A DATA ARRAY
C * NB 1/NB-OCTAVE FREQUENCY BANDS
C * NM NUMBER OF ANGLES
C * PL PERCEIVED NOISE LEVELS, ALL ANGLES
C * CALLS PNDB
C ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
DIMENSION A(27,19),PL(19)
DO 1 J=1,NM
1 CALL PNDB (NB,A(J),PL(J))
PL(J)=DB
RETURN
END
SUBROUTINE ASMBL (R, SL)

/*ASMBL - ASSEMBLE DATA*/

*ASSEMBLES ONE SET OF WORKING DATA FROM COMMON BLOCK /WD/ INTO *
*A REFERRED ARRAY.*

* RADIUS FOR REFERRED ARRAY *

* SL REFERRED ARRAY *

* DIMENSION SL(27,19) *

COMMON /WD/A(20,4), NCONF, RPM, PCS, NF, NM, NB, PWL, SUMN, PSM(27), DT,
1 AI(19), NFIL(27), DI(27,19)

* VARIABLES IN COMMON BLOCK /WD/*

* A(20,4) FOUR CARDS OF ID (WORD LENGTH 4) *

* NCONF CONFIGURATION NUMBER *

* RPM SPEED IN RPM *

* PCS PERCENT SPEED *

* NF NUMBER OF FREQUENCY BANDS *

* NM NUMBER OF ANGLES *

* NB 1/NB-OCTAVE BANDS *

* PWL OVERALL ACOUSTIC POWER LEVEL *

* SUMN DECIBEL SUM OF NORMALIZED POWER SPECTRUM *

* PSM(27) NORMALIZED POWER SPECTRUM *

* DT ANGLE INCREMENT *

* AI(19) ANGLES *

* NFIL(27) BAND CENTER FREQUENCIES *

* DI(27,19) DIRECTIVITY INDEX *

F =3.1415927/180.*

RHO=0.0023769
C=1116.3975
CONST=2.0*59.1415927/180.5E-15
SPHERE=4.0*3.1415927/180.*R**2
NFT=1
NLT=NM
SUM=0.0
IF (AI(1)*.GT.0.0) GO TO 1
SUM=SUM+1.0
NFT=2
1 IF (AI(NM)*.LT.180.0) GO TO 2
SUM=SUM+1.0
NLT=NM-1
2 SUM=TAN(DT/4./F)/2.*SUM
3 DO 3 J=NFT,NLT
3 SUM=SUM+SUM+DI(1,J)
DO 4 J=1,NM
4 SL(I,J)=PSUM+DI(1,J)
RETURN
END
SUBROUTINE ATMAT (T,RH,DIST,FREQ,ATT)

C * ATMAT - ATMOSPHERIC ATTENUATION /
C * COMPUTES EXCESS ATMOSPHERIC ATTENUATION IN DECIBELS FOR GIVEN *
C * TEMPERATURE, RELATIVE HUMIDITY, DISTANCE, AND FREQUENCY. *
C * USES EMPIRICAL CURVE-FITS OF DATA CONTAINED IN SOCIETY OF *
C * AUTOMOTIVE ENGINEERS AEROSPACE RECOMMENDED PRACTICE NO. 866, *
C * AUGUST, 1964.
C * *
C * T TEMPERATURE (DEGREES FAHRENHEIT) *
C * RH RELATIVE HUMIDITY *
C * DIST DISTANCE (FEET) *
C * FREQ FREQUENCY (HFRTZ) *
C * ATT ATTENUATION (DECIBELS) *
C * *

DIMENSION A(22)
DATA A/0.670,0.750,0.652,0.570,0.505,0.452,0.406,0.369,0.335,
1 0.310,0.286,0.260,0.250,0.240,0.231,0.225,0.220,0.215,0.210,
2 0.203,0.202,0.200/AC=(0.1*(FREQ/1000.0)**2.05)/1.651-.001-J3*T)**2.05
AMM=(10.0*(FREQ/1000.0)**1.003)/10.0**(0.52-.00504*(T+SQRT(256.0-1
110.0-T/5.0)**2))
HA=0.25*RH/10.0**(1.493-.01638*T-.02*SQRT(128.2-(10.0-T/5.0)**2))
HMM=1.0**(0.4973*ALOG10(FREQ)-1.4894)
HH=HA/HMM
IF (HH.GT.0.25) GO TO 1
AA=1.2*HH
GO TO 8
1 IF (HH.GT.0.60) GO TO 2
AA=1.543*HH-.086
GO TO 8
2 IF (HH.GT.0.95) GO TO 3
AA=0.84+0.16*SIN(3.14159/2.0*(HH-.6)/.35)
GO TO 8
3 IF (HH.GT.1.25) GO TO 4
AA=0.87+0.13*COS(3.14159/2.0*(HH-.95)/.3)
GO TO 8
4 IF (HH.GT.6.5) GO TO 7
HTEST=1.25
DO 5 I=2,22
HTEST=HTEST+.25
IF (HH.LE.HTEST) GO TO 6
CONTINUE
5 AA=A(I)+((HTEST-HH)/0.25)*(A(I-1)-A(I))
GO TO 8
6 AA=0.2
CONTINUE
7 AA=(AMM*AA+AC)*(DIST/1000.0)
RETURN
END
SUBROUTINE AVSLR (SL, AI, DT, NM, SLR):  
/AVSLR - AVERAGE SL ON AN ARC/  
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  
* * COMPUTES SIMPLE-SOURCE SOUND PRESSURE LEVEL (AREA-WEIGHTED  
* AVERAGE SOUND PRESSURE LEVEL) FROM DIRECTIONAL DATA ON AN ARC.  
* RESULTS USED FOR DIRECTIVITY INDEX CALCULATION.  
* SL REFERRED DATA ON AN ARC  
* AI CORRESPONDING ANGLES  
* DT ANGLE INCREMENT  
* NM NUMBER OF ANGLES  
* SLR AVERAGE SOUND PRESSURE LEVEL  
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  
DIMENSION SL(19), AI(19)  
F = 3.1415927/180.0  
NFT = 1  
NLT = NM  
SUM = 0.0  
SUMD = 0.0  
IF (AI(1).GT.0.0) GO TO 1  
SUM = SUM + 10.0**(SL(1)/10.0)  
SUMD = SUMD + 1.0  
NFT = NM  
IF (AI(NM).LT.180.0) GO TO 2  
SUM = SUM + 10.0**(SL(NM)/10.0)  
SUMD = SUMD + 1.0  
NLT = NM - 1  
1 IF (AI(NM).LT.180.0) GO TO 2  
SUM = SUM + 10.0**(SL(NM)/10.0)  
SUMD = SUMD + 1.0  
NLT = NM - 1  
2 SUM = TAN(DT/4.0*F)/2.0*SUM  
SUMD = TAN(DT/4.0*F)/2.0*SUMD  
DO 3 J = NFT, NLT  
3 SUM = SUM + 10.0**(SL(J)/10.0)*SIN(AI(J)*F)  
SUMD = SUMD + SIN(AI(J)*F)  
SLR = 10.0*ALOG10(SUM/SUMD)  
RETURN  
END
SUBROUTINE BASPAT (A, RT, NF, NO, T, RH, TFA, R, ATA)

C /BASPAT - BAND SPECTRUM ATTENUATION/
C *************************************************
C COMPUTES FRACTIONAL-OCTAVE BAND EXCESS ATMOSPHERIC ATTENUATION
C CONSIDERING SPECTRUM SHAPE. EXTRAPOLATES SPECTRUM TO NEW
C ATTENUATION ACCOUNTING FOR INVERSE SQUARE AND EXCESS ATMOSPHERIC
C attenuaton.
C
A REFERRED SPECTRUM
RT CORRESPONDING RADIUS
NF NUMBER OF FREQUENCY BANDS
NO 1/NB-OCTAVE FREQUENCY BANDS
T TEMPERATURE (DEGREES FAHRENHEIT)
RH RELATIVE HUMIDITY
TFA ATTENUATION IN DECIBELS PER THOUSAND FEET
R RADIUS FOR ATTENUATED SPECTRUM
ATA ATTENUATED SPECTRUM AT R
(INVERSE SQUARE AND ATMOSPHERIC ATTENUATION)
C
CALLS ATMAT
C
DIMENSION A(27),TFA(27),ATA(27)
REAL M(27,2)
NLS=NF-1
DO 1 I=1,NLS
  M(I,2)=A(I+1)-A(I)
  M(I,1)=M(I,2)
M(NF,2)=M(NF,1)
NS=3
S=NS
B=NB
BI=B*2.0*FLOAT(NS)
FL=1.0
IF (NB.EQ.1) FL=10.0**1.8
IF (NB.EQ.3) FL=10.0**1.7
DO 3 I=1,NF
  FC=10.0**(0.3/BI*FLOAT(I-1))*FL
  CALL ATMAT (T, RH, 1000.0, FC, AL)
  CALL ATMAT (T, RH, 1000.0, FR, AR)
  SL=1.0
  SLA = 10.0**(-AC/10.0)
  DO 2 K=1,NS
    XL=-K
    XR=K
    EL=M(I,1)/2.0*XL/S
    ER=M(I,2)/2.0*XR/S
    SL=SL+10.0**(EL/10.0)+10.0**((ER/10.0)
    FL=10.0**(0.3/BI*XL)*FC
    FR = 10.0**(0.3/BI*XR)*FC
    CALL ATMAT (T, RH, 1000.0, FL, AL)
    CALL ATMAT (T, RH, 1000.0, FR, AR)
    SLA=SLA+10.0**((EL-AR/10.0)+10.0**((ER-AR)/10.0)
    TFA(I)=10.0**ALOG10(SL)-10.0**ALOG10(SLA)
    ATA(I)=A(I)-TFA(I)*R/1000.0-20.0*ALOG10(R/RT)
2
RETURN
END
MAIN PROGRAM DADIFF
/DADIFF - DATA DIFFERENCE/

COMPUTES DIFFERENCES BETWEEN TWO SETS OF DATA, INCLUDING
ACOUSTIC POWER, REFERRED ARRAY, AND EXTRAPOLATED DATA.

CALLS
ASMBL, ATMAT, BASPAT, DBSUM, PND, PNL, POWER, TITLE2, WDATA

COMMON A(20,4,2), Al(19,2), NFIL(27,2), NCONF(2), RPM(2), PCS(2),
1 NB(2), NF(2), NM(2), DT(2)
COMMON /WD/ AA(20,4), NCONF, KP, PC, NNF, NNB, PW, SUMN, PS(27), DTT,
1 AA(19), NFIL(27), UI(27,19)
DIMENSION DI(27,19,2), TSL(27,19,2), TBL(27,19,2)
DIMENSION PSM(27,2), AF(19,2), AR(19,2), F(19,2), R(19,2), TW(27,2)
1 TPW(27,2), RPSM(27,2), DIF(27,19)
DIMENSION SUM(19,21), FW(27,21), RW(27,2)
DIMENSION PWL(2), SOM(2), WF(27), WR(27), PWF(2), PWR(2)
1 DELTF(27), UELTR(27), DIFF (29)
DIMENSION PN(19,2), DPN(19,5), TFA(27), ATA(27,19,2), PNT(19,2)
1 PNT(19)
LOGICAL FTEST, ATEST, SPLIT(2)
THREE=10.0*ALOG10(2.0)
T=59.0
RH=70.0
WRITE (6,1)
FORMAT (11H1)
READ (5,2) (S(I),I=1,5)
FORMAT (5F6.0)

INPUT DATA REQUIRED
ONE CARD WITH UP TO FIVE SIDELINE DISTANCES,
OR A BLANK CARD FOR NO SIDELINE EXTRAPOLATIONS.

DO 3 I=1,5
IF (S(I).LE.0.0) GO TO 4
CONTINUE
NS=5
GO TO 5
NS=I-1
CONTINUE
READ, ASSEMBLE TWO SETS OF DATA
DO 10 K=1,2
CALL WDATA
INPUT DATA REQUIRED
ONE OR MORE PAIR OF SETS OF WORKING DATA.
DIFFERENCES TAKEN USING SET TWO MINUS SET ONE.

DC 7 J=1,4
DO 7 I=1,20
7 A(I,J,K)=AA(I,J)
NCONF(K)=NCON
RPM(K)=RP
PCS(K)=PC
NF(K)=NNF
NM(K)=NNM
NB(K)=NNB
PWL(K)=PW
DT(K)=DTT
DO 8 J=1,NNM
8 AI(J,K)=AI(J)
DO 9 I=1,NNF
PSM(I,K)=PSM(I)
NFIL(I,K)=NF(I)
DO 9 J=1,NNM
9 DI(I,J,K)=DI(I,J)
CALL ASM (100.0,TSL(1,1,K))
CONTINUE
FTEST=.TRUE.
ATEST=.TRUE.
SPLIT(1)=.FALSE.
SPLIT(2)=.FALSE.
DO 22 K=1,2
NMM=NM(K)
DO 11 J=1,NMM
IF (AI(J,K).EQ.90.0) GO TO 12
CONTINUE
GO TO 13
SPLIT(K)=.TRUE.
CONTINUE
JS=J
NFF=NF(K)
DO 14 I=1,NFF
DO 14 J=1,NNM
TBL(I,J,K)=TSL(I,J,K)
DO 15 I=1,NFF
15 TSL(I,JS,K)=TSL(I,JS,K)-THREE
DO 16 J=1,JS
AF(J,K)=AI(J,K)
DO 17 J=JS,NMM
1=J-JS+1
17 AR(I,K)=AI(I,K)
NMF=JS
NMR=NMM-JS+1
DO 20 I=1,NFF
DO 20 J=1,JS
18 F(J,K)=TSL(I,J,K)
DO 19 J=JS,NMM
JJ=J-JS+1
19 R(JJ,K)=TSL(JJ,K)
CALL POWER (F(I,K),100.0,AF(I,K),NMF,DT(K),59.0,29.92,FPSE(I,K),FW
1(I,K))
CALL POWER (R(I,K),100.0,AR(I,K),NMR,DT(K),59.0,29.92,RPSE(I,K),RW
1(I,K))
TW(I,K)=FW(I,K)+RW(I,K)
TPWL(I,K)=130.0+10.0*ALOG10(TW(I,K))
CONTINUE
WF(K)=0.0
W(K)=0.0
WF(K)=0.0
20
DO 21 I=1,NFF
WF(K)=WF(K)+FW(I,K)
W(K)=W(K)+TW(I,K)
WR(K)=WR(K)+RW(I,K)
PW(K)=130.0*10.0*WLOG10(WF(K))
PWL(K)=130.0*10.0*WLOG10(W(K))
PWR(K)=130.0*10.0*WLOG10(WR(K))
CONTINUE
DPWL=PWL(2)-PWL(1)
NFF=MINO(NF(1),NF(2))
DO 23 I=1,NFF
IF (NFIL(I,1).NE.NFIL(I,2)).F.T. FTEST=.FALSE.
CONTINUE
C
C SHIFT SPECTRUM ARRAYS TO GET FREQUENCY CORRESPONDENCE
C
IF (NB(1).EQ.NB(2).AND..NOT.FTEST) GO TO 24
GO TO 30
IF (NFIL(1,2).GT.NFIL(1,1)) GO TO 25
LL=2
LH=1
GO TO 26
LL=1
LH=2
CONTINUE
II=NF(LL)
DO 27 I=1,II
IF (NFIL(I,LL).EQ.NFIL(I,1)) GO TO 28
CONTINUE
II=NF(LL)
DO 29 I=1,II
K=I+ID-1
NFIL(I,LL)=NFIL(K,LL)
JJ=NM(LL)
DO 29 J=1,JJ
TBL(J,I,LL)=TBL(K,J,LL)
NFF=MINO(NF(1),NF(2))
FTEST=.TRUE.
C
C SHIFT ANGLE ARRAYS TO GET ANGLE CORRESPONDENCE
C
IF (AI(1,2).GT.AI(1,1)) GO TO 32
LL=2
LH=1
GO TO 33
LL=1
LH=2
CONTINUE
JJ=NM(LL)
DO 34 J=1,JJ
IF (AI(J,J,LL).EQ.AI(1,LH)) GO TO 35
CONTINUE
GO TO 37
JD=J
NM(LL)=NM(LL)-JD+1
JJ=NM(LL)
DO 36 J=1, JJ
K=J+JD-1
AI(J,LL)=AI(K,LL)
II=NF(LL)
DO 36 I=1,II
36 TBL(I,J,LL)=TBL(I,K,LL)
NMM=MIN(NM(1),NM(2))
ATEST=.TRUE.
C
PAGE ONE OUTPUT
C
37 CONTINUE
CALL TITLE2
WRITE (6,38)
38 FORMAT (1H, 40X, 45HP OWER L EVEL D IFFERENCES//
147X, 33H(DATA SET TWO MINUS DATA SET ONE)//}}
IF (FTEST.AND.SPLIT(I).AND.SPLIT(2)) GO TO 45
WRITE (6,39) PWL(2),PWL(1),DPWL
39 FORMAT (1H, 22X, 1HTOTAL POWER/15X, 27HSET TWO SET ONE DELTA PWL
1//4X, 8HOVERALL , 3F9.1)
IF (FTEST) GO TO 41
WRITE (6,40)
40 FORMAT (1H, 1H2, 30X, 83H(FREQUENCIES INCOMPATIBLE FOR COMPARISON, NO 90
1 DEGREE ANGLE TO PERMIT 90/90 SPLIT))
GO TO 54
41 WRITE (6,42)
42 FORMAT (1H, 3X, 8HPOWER ALL, 8HOVERALL , 3F9.1/15H BAND FREQUENCY)
DO 43 I=1,NFF
DELTA=TPWL(I,2)-TPWL(I,1)
43 WRITE (6,44) I,NFIL(I,1),TPWL(I,2),TPWL(I,1),DELTA
44 FORMAT (1H, 13, 18, 3F9.1)
GO TO 54
45 WRITE (6,46)
46 FORMAT (1H, 22X, 1HTOTAL POWER, 45X, 14HFRONT QUADRANT, 19X, 13HRear Q
1UADRANT//15X, 27HSET TWO SET ONE DELTA PWL, 26X, 2(5X, 27HSET TWO S
2ET ONE DELTA PWL)///)
DPF=PWF(2)-PWF(1)
DPR=PWR(2)-PWR(1)
WRITE (6,47) PWL(2),PWL(1),DPWL,PWF(2),PWF(1),DPF,PWR(2),PWR(1),DP
1R
47 FORMAT (1H, 3X, 8HPOWER ALL, 3F9.1/24X, 8HPOWER ALL, 3F9.1, 5X, 3F9.1)"
IF (FTEST) GO TO 49
WRITE (6,48)
48 FORMAT (1H, 1H2, 41H(FREQUENCIES INCOMPATIBLE FOR COMPARISON))
GO TO 54
49 WRITE (6,50)
50 FORMAT (1H, 15H BAND FREQUENCY, 45X, 14HBAND FREQUENCY)
DO 51 I=1,NFF
DELF(I)=FPSM(I,2)-FPSM(I,1)
51 FORMAT (1H, 15, 18, 3F9.1)
DO 52 I=1,NFF
DELTR(I)=RPSM(I,2)-RPSM(I,1)
52 FORMAT (1H, 15, 18, 3F9.1)
GO TO 54
53 WRITE (6,53)
53 FORMAT (1H, 13, 18, 3F9.1, 21X, 13, 18, 3F9.1, 5X, 3F9.1)
C
PAGE TWO OUTPUT
C
54 WRITE (6,1)
CALL TITLE2
WRITE (6,55)
55 FORMAT (1H, 32X, 61HDIFFERENCES OF REFERRED 249
DATA //47X,33H(DATA SET TWO MINUS DATA SET ONE)//)

IF (ATEST) GO TO 57
WRITE (6,56)

56 FORMAT (1H2,45H(DATA SET ANGLES INCOMPATIBLE FOR COMPARISON))
GO TO 6
WRITE (6,58) (AI(J,1),J=1,NMM)

58 FORMAT (1H ,9X,5HANGLE,19F6.0)
WRITE (6,59)

59 FORMAT (/)
DO 60 K=1,2
DO 60 J=1,NMM

60 CALL OBSUM (TBL(1,J,K),NFF,SUM(J,K))
DO 61 J=1,NMM

61 DIFF(J)=SUM(J,2)-SUM(J,1)
WRITE (6,62)

62 FORMAT (1H ,7X,7HOVERALL,19F6.0)
IF (FTEST) GO TO 64
WRITE (6,63)

63 FORMAT (1H2,30X,50H(DATA SET FREQUENCIES INCOMPATIBLE FOR COMPARISON))
GO TO 69
DO 65 I=1,NFF
DO 65 J=1,NMM

65 DIF(I,J)=TBL(I,J,2)-TBL(I,J,1)
WRITE (6,66)

66 FORMAT (1H ,14HBAND FREQUENCY)
DO 67 I=1,NFF

67 WRITE (6,68) I,NF(I,L(1,1),OIF(I,J),J=1,NMM)

68 CONTINUE
C
PAGE THREE OUTPUT
C
IF (NS.LE.0) GO TO 6 ' -.
WRITE (6,1)
CALL TITLE2
WRITE (6,70) T,RH

70 FORMAT (1H ,20X,83HPERCEIVED AND TONE-CORRECTED RECEIVED NOISE LEVELS AND DIFFERENCES ALONG SIDELINES///5GX , F5.1///5X, F5.1,11H PERCENT RH)
DO 81 KK=1,NS:

81 IF (KK.EQ.3.0R.KK.EQ.5) WRITE (6,1)
IF (KK.EQ.3.0R.KK.EQ.5) CALL TITLE2
IF (KK.EQ.3.0R.KK.EQ.5) WRITE (6,70) T,RH
DO 71 K=1,2

71 NM1=1
IF (AI(K,1,1).LE.0.0) NM1=2
IF (AI(NMM,1,1).GE.1.00.0) NMM=NMM-1
DO 72 J=NM1,NMM

72 RDIST=S(KK)/SIN(AI(J,1,1)*3.1415927/180.0)
CALL BASPAT (TBL(1,J,1),100.0,NFF,NB,T,RH,TFA,ROIST,ATA(1,J,1))
71 CALL PNLT (ATA(1,J,1),PNL(J,1),PNL(J,2))

72 CONTINUE
C
DO 77 J=NM1,NMM

77 DPNL(1,J)=PNL(1,J,2)-PNL(1,J,1)
WRITE (6,73) (AI(I,1,1),J=NM1,NMM)

73 FORMAT (1H ,11X,F6.0,12H FT SIDELINE///5X,5HANGLE,5X,19F6.0)
WRITE (6,74) (PNL(J,1,2),J=NM1,NMM)

74 FORMAT (1H0,1X,12HSET TWO PNDB,1X,19F6.1)
WRITE (6,75) (PNL(I,1,1),J=NM1,NMM)

75 FORMAT (1H0,1X,12HSET ONE PNDB,1X,19F6.1)
WRITE (6,76) (DPNL(I,J),J=NM1,NMM)

76 FORMAT (1H0,1X,HUELTACNDB,3X,19F6.1)
DO 77 J=NM1,NMM

77 CONTINUE
SUBROUTINE OBSUM (A, N, SUM)  
*UBSUM - DECIBEL SUM/  
*UTILITY ROUTINE TO COMPUTE A DECIBEL SUM (ANTILOGARITHMIC SUM)  
*FOR A NUMBER OF LEVELS.  
*A ARRAY OF DECIBEL VALUES  
*N NUMBER OF VALUES  
*SUM DECIBEL SUM  
DIMENSION A(27)  
SUM=0.0  
DO 1 I=1,N  
1 SUM=SUM+10.0**(A(I)/10.0)  
SUM=10.0*ALOG10(SUM)  
RETURN  
END
SUBROUTINE FARDTA (SL,RT,NF,NB,NM,AL,T,RH,DIST,IC,FARSL)
/FARDTA - FAR DATA/

* EXTRAPOLATES REFERRED ARRAY TO A FAR FIELD RADIUS OR SIDELINE
* ACCOUNTING FOR INVERSE SQUARE AND EXCESS ATMOSPHERIC ATTENUATION.

* SL REFERRED ARRAY
* RT CORRESPONDING RADIUS
* NF NUMBER OF FREQUENCY BANDS
* NB 1/NB-OCTAVE FREQUENCY BANDS
* NM NUMBER OF ANGLES
* AI ANGLES
* T TEMPERATURE (DEGREES FAHRENHEIT)
* RH RELATIVE HUMIDITY
* DIST DISTANCE FROM SOURCE FOR EXTRAPOLATION
* IC CONTROL. IF IC EQUALS ZERO, DIST IS TAKEN AS A RADIUS ABOUT THE SOURCE. IF IC = 1, DIST IS TAKEN AS NORMAL DISTANCE TO A PARALLEL SIDELINE.
* FARSL EXTRAPOLATED DATA ARRAY ON A RADIUS OR SIDELINE
* CALLS BASPAT

DIMENSION SL(27,19),AI(19),FARSL(27,19),TFA(27)
RDIST=DIST
F=3.1415927/180.0
DO 6 J=1,NM
IF (IC.EQ.0) GO TO 3
IF (IC.EQ.1) GO TO 2
WRITE (6,1)
1 FORMAT (62H SIDELINE OR RADIUS NOT CORRECTLY SPECIFIED, SUBROUTINE FARDTA), RETURN
ST=SIN(AI(J)*F)
IF (ST.LE.0.0) GO TO 4
RDIST=DIST/ST
CALL BASPAT (SL(1, J), RT, NF, NB, T, RH, TFA, RDIST, FARSL(1, J))
GO TO 6
DO 5 I=1,NF
5 FARSL(I,J)=0.0
CONTINUE
RETURN
END

SUBROUTINE GRAPH (SL,NF)
/GRAph - GRAPH OUTPUT ON PRINTER/

* UTILITY ROUTINE TO PRINT GRAPH OF A NORMALIZED ARRAY.
* SL NORMALIZED ARRAY
* NF NUMBER OF ELEMENTS OF ARRAY

DIMENSION SL(27),P(132),D(4)
DATA BLANK/IN/

DATA X, PI, ZERO, SIGN, C/HG, 1/H1, 1/H0, 1/-, 1/H1, 1/H2, 1/H3, 1/H4/
WRITE (6, 1)
1 FORMAT (50X, 34HNORMALIZED POWER SPECTRUM ///)
DO 2 I=1, NF
2 SL(I)=ABS(SL(I))
DO 9 L=1, 41
3 P(J)=BLANK
20 P(24)=PI
P(4*NF+20)=PI
IF (L.EQ.1) P(21)=ZERO
IF (L.EQ.11) GO TO 4
IF (L.EQ.21) GO TO 4
IF (L.EQ.31) GO TO 4
IF (L.EQ.41) GO TO 4
GO TO 7
4 P(20)=SIGN
P(22)=ZERO
K=L/10
P(21)=D(K)
IF (L.EQ.41) GO TO 5
GO TO 7
5 KK=4*NF+19
DO 6 K=25, KK
6 P(K)=SIGN
A=FLOAT(L-1)-0.5
B=FLOAT(L-1)+0.5
DO 8 I=1, NF
8 CONTINUE
WRITE (6, 10) (1P(I), I=1, 132)
10 FORMAT (1H 132A1)
WRITE (6, 11) (I, I=1, NF)
11 FORMAT (/21X, 27I4)
RETURN
END

C MAIN PROGRAM LIST
C /LIST - LIST DATA ON PRINTER/
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C * READS, ASSEMBLES SETS OF WORKING DATA AND PREPARES PRINTED
C * OUTPUT IDENTICAL WITH THAT OF WOOG COMMENCING WITH REFERRED
C * ARRAY.
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C COMMON /WO/A(20,4), NCONF, KPM, PCS, NF, NM, NB, PWL, SUMN, PSM(27), DT,
1 AI(19), NFIL(27), DI(27,19)
VARIABLES IN COMMON BLOCK /Wl/

A(20,4) FOUR CARDS OF IT (WORD LENGTH 4)
NCONF CONFIGURATION NUMBER
KPM SPEED IN RPM
PCS PERCENT SPEED
NF NUMBER OF FREQUENCY BANDS
NM NUMBER OF ANGLES
NH 1/NB-OCTAVE BANUS
PWL OVERALL ACOUSTIC POWER LEVEL
SUMN DECIBEL SUM OF NORMALIZED POWER SPECTRUM
PSM(27) NORMALIZED POWER SPECTRUM
DT ANGLE INCREMENT
AI(19) ANGLES
NFIL(27) BAND CENTER FREQUENCIES
DI(27,19) DIRECTIVITY INDEX

DIMENSION BUF(27,19),TFA(27,19),SL(27,19)
DIMENSION AM(19)
DIMENSION B(27),C(27),D(27),E(27),SLR(27)
DIMENSION DS(6),SD(5)

DEFINE NUMBER OF SIDELINE DISTANCES

READ (5,1) RSTD,(SU(I),I=I,5)
FORMAT (6F6.0)

CALL WDATA

INPUT DATA REQUIRED
ONE CARD WITH UP TO FIVE SIDELINE DISTANCES,
OR A BLANK CARD FOR NO SIDELINE EXTRAPOLATIONS.

DO 2 I=1,5
IF (SU(I).LE.0.0) GO TO 3
CONTINUE
NR=5
GO TO 4
CONTINUE
NR=I-1
CONTINUE
2
3
4
CALL WDATA

INPUT DATA REQUIRED
ONE OR MORE SETS OF WORKING DATA TO BE LISTED.

CALL ASMBL (RSTD,SL)

TITLE PAGE

WRITE (6,6)
FORMAT (1H1)
WRITE (6,7)
FORMAT (1H4,46X,35HNOISE DATA LISTED///52X,26H Computed from Working Data///64X,2HUF///)
DO 8 J=1,4
WRITE (6,9) (A(I,J),I=1,2J)
9 FORMAT (30X,20A4)
WRITE (6,10)
10 FORMAT (/)
WRITE (6,11) NCONF,PCS,RPM,NF,NB,NFIL(I),NFIL(NF),NM,DT,AI(1),AI(NM)
11 FORMAT (1H,31X,13HCONFIGURATION,I4,10X,F5.1,14H PERCENT SPEED,10X,
1,F8.6,4H RPM/43X,12,5H - I,1,11,18H OCTAVE BANDS FROM,15,3H TO,16,
26H HERTZ//42X,13,13H ANGLES EVERY,F4.0,13H DEGREES FROM,F5.0,3H TO
3,F5.0)

C PAGE THREE
C REFERRED ARRAY
C
CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,12) RSTD
12 FORMAT (52X.27HR EFERRED A R R A Y//33X,7HDATA AT,F6.1,42H
1 FT RADIUS WITH NO ATMOSPHERIC ATTENUATION/45X,40H(FOR POWER AND D
2RECTIVITY COMPUTATIONS)///)
CALL ANGLE (AI,NM)
CALL OASPL (SL,NM,NF,E)
WRITE (6,13) (E(I),I=1,NM)
13 FORMAT (15H COMPUTED OASPL,19F6.1)
WRITE (6,10)
CALL TBLOP (SL,NF,NFIL,NM,1)

C PAGE FOUR
C ACOUSTIC POWER
C
W=1.0*E-13*10.0**(PWL/10.0)
CALL AVSLR (E,AI,DT,NM,SLRO)
C COMPUTE POWER SPECTRUM
C
DO 14 I=1,NF
14 C(I)=PWL-SUMN+PSM(I)
DO 16 I=1,NF
15 DO 16 J=1,NM
9 DO 15 J=1,NM
16 CALL AVSLR (D,AI,DT,NM,SLR(I))
PWL,W
NORMALIZED POWER SPECTRUM (GRAPH)

PAGE SIX
DIRECTIVITY INDEX

C
CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,23)
FORMAT (50X,33H DIRECTIVITY INDEX//)
CALL ANGLE (AI,NM)
CALL TBLOP (DI,NF,NFIL,NM,1)
CALL AVSLR (E, AI, DI, NM, D10)
DO 24 J=1,NM
E(J)=E(J)-D10
WRITE (6,25) (E(J),J=1,NM)
FORMAT ('8X,7HOVERALL,19F6.1')

C
PAGE SEVEN
ATMOSPHERIC ATTENUATION

DO 26 J=1,NM
CALL BASPAT (SL(I,J), RSTD, NF, NB, 59.0, 70.0, TFA(I,J), RSTD, B)
CALL TITLE (A,NCONF,RPH!,PCS)
WRITE (6,27)
FORMAT (43X,45H ATMOSPHERIC ATTENUATION//)
161HSTANDARD DAY EXCESS ATMOSPHERIC ATTENUATION PER THOUSAND FEET//
237X,56HCOMPUTED FROM REFERRED ARRAY CONSIDERING SPECTRUM SHAPES//)
CALL ANGLE (AI,NM)
CALL TBLOP (TFA,NF,NFIL,NM,1)

C
PAGE EIGHT
STANDARD DAY DATA ATMOSPHERIC ABSORPTION

DO 29 J=1,NM
DO 29 I=1,NF
BUF(I,J)=TFA(I,J)*RSTD/1000.G
CALL ANGLE (AI,NM)
CALL TBLOP (BUF,NF,NFIL,NM,1)

C
PAGE NINE
STANDARD DAY DATA

DO 31 J=1,NM
DO 31 I=1,NF

C
CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,30) RSTD
FORMAT (48X,33HT STANDARD DAY DATA EXCESS AT.
1TMOSPHERIC ATTENUATION//43X,7HDATA AT,F6,10H FT RADIUS//)
DO 33 J=1,NM
DO 33 I=1,NF
31  BUF(I,J)=SL(I,J)-BUF(I,J)
    CALL ANGLE (AI,NM)
    CALL OASPL (BUF,NM,NF,N,F)
    WRITE (6,13) (B(I),I=1,NM)
    WRITE (6,10)
    CALL THLOP (BUF,NF,NFIL,NM,1)
    WRITE (6,13)
    WRITE (6,32) RSTD

32  FORMAT (44X,18HPERCEIVED NOISE ON,F8.1,17H FT RADIUS, PNDB//)
    CALL ANGLE (AI,NM)
    CALL APNDB (BUF,NB,NM,F)
    WRITE (6,33) (B(I),I=1,NM)

33  FORMAT (15X,19F6.1)

34  DO 34 J=1,MM
    AM(J)=AI(J)
    IF (AM(J).GT.0.0) GO TO 36
    MM=MM-1
    DO 35 J=1,MM
    AM(J)=AM(J+1)
    DO 35 I=1,NF
    SL(I,J)=SL(I,J+1)

35  IF (AM(MM).LT.130.0) GO TO 37
    MM=MM-1

36  CONTINUE

37  CONTINUE

38  DO 38 J=1,MM
    DO 39 I=1,NF
    BUF(I,J)=SL(I,J)-B(J)-TFA(I,J)*C(J)/1000.0
    CALL ANGLE (AI,NM)
    CALL OASPL (BUF,NM,NF,N,F)
    WRITE (6,13) (C(J),J=1,MM)

39  FORMAT (44X,18HPERCEIVED NOISE ON,F8.1,17H FT RADIUS, PNDB//)
    CALL ANGLE (AI,NM)
    CALL OASPL (BUF,NM,NF,N,F)
    WRITE (6,33) (B(I),I=1,NM)

40  FORMAT (44X,18HPERCEIVED NOISE ON,F8.1,17H FT RADIUS, PNDB//)
    CALL ANGLE (AI,NM)
    CALL OASPL (BUF,NM,NF,N,F)
    WRITE (6,33) (B(I),I=1,NM)
IF (NX.LE.0) GO TO 45
CONTINUE
WRITE (6,6)
GO TO 5
END

SUBROUTINE OASPL (A,NM,NF,OA)
DIMENSION A(27,19),OA(19)
DO 1 J=1,NM
CALL OBSUM (A(1,J),NF,SUM)
OA(J)=SUM
RETURN
END

SUBROUTINE PNDB (NB,LB,PNL,NC)
DIMENSION LB(8,24)
DO 1 J=1,NB
CALL OBSUM (LB(1,J),NF,SUM)
PNL=SUM/14.2857
RETURN
END
REAL LB(27),NOY(24),K,NMAX,NDBK,MJ,LK
REAL L(24,5),M(24,4)
DATA L/49.0,44.0,39.0,34.0,30.0,27.0,24.0,21.0,18.0,5*16.0,15.0,14.0,13.0,12.0,11.0,10.0,9.0,8.0,7.0,6.0,5.0,4.0,3.0,2.0,1.0,0.0/
DATA M/0.079520,2*0.068160,0.059640,10*0.053013,0.059640,12*0.053013,2*0.047712,2*0.053013,0.068160,0.079520,0.059640,22*0.058098,0.052288,0.047712,2*0.043573,0.037349,37*0.034659,0.040221,0.037349,4*0.034659,0.043573,40.043573,0.040221,0.034659,0.037349,0.034659,2*0.030103,0.029960,2*0.042285,15*0.030103,9*0.029960,
IF (NB.EQ.1) GO TO 2
IF (Na.EQ.3) GO TO 3
WRITE (6,1) .
1 FORMAT (30H FREQUENCY BANDWIDTH IMPROPERLY SPECIFIED/4TH FREQUENCY BANDWIDTH IMPROPERLY SPECIFIED/47H RETURN TO CALLING PROGRAM WITH PNDB EQUAL ZE)
RETURN
2 NF=8
K=0.3
MM=3
LL=1
GO TO 4
3 NF=24
K=0.15
MM=1
LL=0
CONTINUE
NMAX=0.0
SUMN=0.0
DO 12 I=1,NF
J=MM*1-LL
IF (LB(I).LT.L(J,1)) GO TO 6
IF (L(J,1).LE.LB(I).AND.LB(I).LT.L(J,2)) GO TO 7
IF (L(J,2).LE.LB(I).AND.LB(I).LT.L(J,3)) GO TO 8
IF (L(J,3).LE.LB(I).AND.LB(I).LT.L(J,5)) GO TO 9
IF (L(J,5).LE.LB(I).AND.LB(I).LT.L(J,150.0)) GO TO 10
IF (LB(I).EQ.150.0) GO TO 10
WRITE (6,5) LB(I)
WRITE (6,5) LB(I)
5 FORMAT (30H PNDB SUBROUTINE ERROR MESSAGE/F6.1,68H PNDB EXCEEDS RANGE FOR VALID PNDB CALCULATION. RETURN WITH PNDB = 0.)
1GE FOR VALID PNDB CALCULATION. RETURN WITH PNDB = 0.)
RETURN
6 NOY(I)=0.0
GO TO 12
7 MJ=M(J,1)
LK=L(J,1)
A=0.1
GO TO 11
8 MJ=M(J,2)
LK=L(J,3)
A=1.0
GO TO 11
9 MJ=M(J,3)
LK=L(J,3)
A=1.0
GO TO 11
10 CLEAR ALL
11 WRITE (6,1) .
12 FORMAT (30H FREQUENCY BANDWIDTH IMPROPERLY SPECIFIED/4TH FREQUENCY BANDWIDTH IMPROPERLY SPECIFIED/47H RETURN TO CALLING PROGRAM WITH PNDB EQUAL ZE)
RETURN
END
INTEGER FREQ(24)
DATA FREQ/50,63,80,100,125,160,200,250,315,400,500,630,800,1000/
1,1250,1600,2000,2500,3150,4000,5000,6300,8000,10000/!
DO 1 I=1,24
   IF (SL(I).LT.0.0) SL(I)=0.0
   N(I)='.FALSE.'
   DO 2 I=4,24
      M(I)=SL(I)-SL(I-1)
      DO 3 I=5,24
         IF (ABS(M(I)-M(I-1)).LE.5.0) GO TO 3
         IF (M(I).GT.0.0.AND.M(I).GT.M(I-1)) N(I)='.TRUE.'
         IF (M(I).LE.0.0.AND.M(I-1).GT.0.0) N(I-1)='.TRUE.'
      CONTINUE
   3 CONTINUE
   DO 6 I=1,24
      IF (.NOT.N(I)) GO TO 4
      IF (I.EQ.24) GO TO 5
      SLP(I)=(SL(I-1)+SL(I+1))/2.0
   4 SLP(I)=SL(I)
   GO TO 6
   5 SLP(24)=SL(23)+M(24)
   6 CONTINUE
   DO 7 I=4,24
      M(I)=SLP(I)-SLP(I-1)
      M(3)=M(4)
      M(25)=M(24)
   7 CONTINUE
   DO 8 I=3,23
      SBAR(I)=(M(I)+M(I+1)+M(I+2))/3.0
      SLP(3)=SL(3)
   8 SBAR(I)=M(I)+M(I+1)+M(I+2))/3.0
   9 SLP(I)=SLP(I-1)+SBAR(I-1)
   TMAX=0.0
   T=0.0
   DO 14 I=3,24
      F(I)=SL(I)-SLP(I)
      IF (F(I).LE.9.0) GO TO 14
      IF (500.LE.FREQ(I).AND.FREQ(I).LT.500) GO TO 10
      IF (5000.LE.FREQ(I).AND.FREQ(I).LE.10000) GO TO 10
      GO TO 11
   10 IF (F(I).LT.3.0) T=0.0
      IF (3.0.LE.F(I).AND.F(I).LT.20.0) T=F(I)/6.0
      IF (20.0.LE.F(I)) T=3.0+1.0/3.0
      GO TO 13
   11 IF (5000.LE.FREQ(I).AND.FREQ(I).LE.5000) GO TO 12
      GO TO 14
   12 IF (F(I).LT.3.0) T=0.0
      IF (3.0.LE.F(I).AND.F(I).LT.20.0) T=F(I)/3.0
      IF (20.0.LE.F(I)) T=6.0+2.0/3.0
   13 IF (T.LE.TMAX) TMAX=T
   14 CONTINUE
   CALL PNDDB (3,SL,PDB,0)
   DBT=PDB+TMAX
   RETURN
END
SUBROUTINE POWER (A,R,AI,NM,DT,BAR,PWL,W)
/POWER - TOTAL ACOUSTIC POWER/
* COMPUTES TOTAL ACOUSTIC POWER BY INCREMENTAL AREA SUMMATION *
* FOR A SET OF ANGLES AND REFERRED SOUND PRESSURE LEVELS ON AN *
* ARC. PRESENCE OF PERFECTLY REFLECTIVE GROUND PLANE ASSUMED. *
* A ARRAY OF REFERRED SPL DATA ON AN ARC *
* R ARC RADIUS *
* AI CONSECUTIVE ANGLES CORRESPONDING WITH ELEMENTS OF A *
* NM NUMBER OF ANGLES *
* DT ANGLE INCREMENT *
* T TEMPERATURE (DEGREES FAHRENHEIT) *
* BAR BAROMETER (INCHES HG) *
* PWL POWER LEVEL RE 0.1 PICOWATT *
* W ACOUSTIC POWER, WATTS *
* *
DIMENSION A(27),AI(19)
CONST=2.0*59.141053*1.0E-15
SPHERE=4.0*3.1415927*R**2
C=49.02*SQR(T+459.67)
RHO=0.0023769*518.688/(T+459.67)*BAR/29.92
F=3.1415927/180.0
NFT=1
NLT=NM
SUM=0.0
IF (AI(1).GT.0.0) GO TO 1
SUM=SUM+10.0**(A(1)/10.0)
NFT=2
1 IF (AI(NM).LT.180.0) GO TO 2
SUM=SUM+10.0**(A(NM)/10.0)
NLT=NM-1
2 SUM=TAN(DT/4.0*F)*SUM/2.0
DO 3 J=NFT,NLT
3 SUM=SUM+10.0**(A(J)/10.0)*SIN(AI(J)*F)
W=CONST/(RHO*C)*SPHERE*SUM/2.0
PWL=130.0+10.0*ALOG10(W)
RETURN
END

SUBROUTINE SIDLAT (NM, AI, RSTD, SIDIST, SINAT, RADIST)
/SIDLAT - SIDELINE ATTENUATION/
* UTILITY ROUTINE TO COMPUTE SIDELINE RADIAL DISTANCES AND *
* ATTENUATIONS FOR ALL ANGLES. *
* NM NUMBER OF ANGLES *
* AI ANGLES *
* RSTD ARC RADIUS ABOUT SOURCE *
* SIDIST NORMAL DISTANCE, SOURCE CENTERLINE TO PARALLEL *
* SIDELINE *
* SINAT INVERSE SQUARE ATTENUATIONS IN DECIBELS *
* RADIST RADIAL DISTANCES, SOURCE TO SIDELINE *
*

DIMENSION: A(19), SINAT(19), RADIST(19)

F = 3.1415927/180.0

RSQ = 20.0 * ALOG10(SIDIST/RSTD)

00 J = 1, NM

ST = SIN(AI(J)*F)

IF (ST.LT.0.0) GO TO 1

SINAT(J) = RSQ - 20.0 * ALOG10(ST)

RADIST(J) = SIDIST/ST

GO TO 2

SINAT(J) = 0.0

RADIST(J) = 0.0

CONTINUE

RETURN

END

SUBROUTINE TABLE (RSTD, SD)

/TABLE - TABLE OF DATA FOR REPORTING/

C
C

* READS WORKING DATA AND PREPARES A TABLE OF NOISE DATA IN A
C

* FORMAT SUITABLE FOR REPORTING PURPOSES. DATA INCLUDES
C

* STANDARD-DAY 1/3-OCTAVE BAND AND OVERALL SOUND PRESSURE
C

* LEVELS ON AN ARC, OVERALL POWER LEVEL AND POWER SPECTRUM,
C

* CORRESPONDING SIMPLE SOURCE SOUND PRESSURE LEVELS, AND
C

* OPTIONAL PERCEIVED NOISE LEVELS ON SELECTED SIDELINES.
C

* NOTE
C

* PROGRAM LOGIC AND FORMAT STATEMENTS CODED FOR NB = 3, AND
C

* NM = 16. CODING MUST BE REVISED FOR OTHER CONDITIONS.
C

* RSTD RADIUS FOR WHICH DATA TO BE PREPARED
C

* SD OPTIONAL SIDELINE DISTANCES FOR PERCEIVED NOISE
C

* CALLS ASMBL, AVSLR, DBSUM, FARDTA, PNDB, WDATA
C

* COMMON /WD/A(20, 4),NCONF, RPM, PCS, NF, NM, NB, PWL, SUMN, PSM(27), DT,
C

* 1 AI(19), NFIL(27), DI(27, 19)
C

* VARIABLES IN COMMON BLOCK/WD/
C

* A(20, 4) FOUR CARDS OF ID (WORD LENGTH 4)
C

* NCONF CONFIGURATION NUMBER
C

* RPM SPEED IN RPM
C

* PCS PERCENT SPEED
C

* NF NUMBER OF FREQUENCY BANDS
C

* NM NUMBER OF ANGLES
C

* NB 1/NB-OCTAVE BANDS
C

* PWL OVERALL ACOUSTIC POWER LEVEL
C

* SUMN DECIBEL SUM OF NORMALIZED POWER SPECTRUM
C

* PSM(27) NORMALIZED POWER SPECTRUM
C

* DT ANGLE INCREMENT
C

* AI(19) ANGLES
C

* NFIL(27) BAND CENTER FREQUENCIES
C

* DI(27, 19) DIRECTIVITY INDEX
C

*
**INPUT DATA REQUIRED**

**ONE SET OF WORKING DATA FOR EACH SUBROUTINE CALL.**

```fortran
CALL WDATA

CALL ASMBL (RSTD, SL)
DO 2 J=1,NF
   CALL AVSLR (B, AI, DT, NM, AVSPL(I))
   DO 3 J=1,NM
      B(J)=SL(I,J)
      CALL DBSUM (SL(1,J), NF, OASL(J))
   END

DO 4 J=1,NM
   CALL ORSUM (SLR(1,J), NF, OASPL(J))
   DO 5 I=1,NF
      PW(I)=PWL-SUMN+PSM(I)
   END

WRITE (6,6) ":")
6 FORMAT (1HO,23X,87HOATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 170 PERCENT RELATIVE HUMIDITY)
WRITE (6,7) ":")
7 FORMAT (1H ,35X,20HSPL RE .00002 N/SQ M,10X,18HPWL RE .1 PICOWATT)
DO 8 I=1,NM
   IAI(I)=AI(I)
   WRITE (6,9) ":")
9 FORMAT (1H ,10X,17I6)
RMETER=RSTO*0.3048
WRITE (6,11) RMETER
11 FORMAT (1H+,113X,3HSPL,3X,5H(PWL)//30X,46Hl/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON,FM.1,13H METER RADIUS//)
DO 13 I=1,NF
   WRITE (6,12) NFI(I), (SLR(1,J), J=1,NM), AVSPL(I), PW(I)
12 FORMAT (1H ,11X,2X,18X,10HANGLE, DEC,45X,6HSIMPLE,2X,5HPOWER//46X,6HSOURCE,2X,5HLEVEL)
13 IF (MOD(I,3).EQ.0) WRITE (6,14)
14 FORMAT (1H )
15 FORMAT (1H )
16 IF (SU(I).LE.0.0) GO TO 17
17 CONTINUE
WRITE (6,19) ":")
19 FORMAT (1H0,2X,8HDISTANCE,35X,31HSIDELINE PERCEIVED NOISE LEVELS//)
   DO 21 I=1,IS
      CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
   END
   DO 2 J=1,NM
      CALL ORSUM (SLR(1,J), NF, OASPL(J))
   END
DO 21 I=1,IS
 CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
DO 2 J=1,NM
   CALL ORSUM (SLR(1,J), NF, OASPL(J))
   DO 3 J=1,NM
5 CALL URSUM (SLR(1,J), NF, OASPL(J))
   DO 5 I=1,NF
4 CALL ORSUM (SLR(1,J), NF, OASPL(J))
   DO 4 J=1,NM
3 CALL DBSUM (SL(1,J), NF, OASL(J))
   CALL AVSLR (OASL, AI, DT, NM, AVGOA)
   CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
   DO 3 J=1,NM
CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
   DO 2 J=1,NM
CALL ASMBL (RSTD, SL)
   CALL AVSLR (B, AI, DT, NM, AVSPL(I))
   DO 2 J=1,NM
      B(J)=SL(I,J)
      CALL DBSUM (SL(1,J), NF, OASL(J))
   END
```

**INPUT DATA REQUIRED**

**ONE SET OF WORKING DATA FOR EACH SUBROUTINE CALL.**

```fortran
CALL WDATA

CALL ASMBL (RSTD, SL)
DO 2 J=1,NF
   CALL AVSLR (B, AI, DT, NM, AVSPL(I))
   DO 3 J=1,NM
      B(J)=SL(I,J)
      CALL DBSUM (SL(1,J), NF, OASL(J))
   END

DO 4 J=1,NM
   CALL ORSUM (SLR(1,J), NF, OASPL(J))
   DO 5 I=1,NF
      PW(I)=PWL-SUMN+PSM(I)
   END

WRITE (6,6) "")
6 FORMAT (1HO,23X,87HOATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 170 PERCENT RELATIVE HUMIDITY)
WRITE (6,7) ")")
7 FORMAT (1H ,35X,20HSPL RE .00002 N/SQ M,10X,18HPWL RE .1 PICOWATT)
DO 8 I=1,NM
   IAI(I)=AI(I)
   WRITE (6,9) "")
9 FORMAT (1H ,10X,17I6)
RMETER=RSTO*0.3048
WRITE (6,11) RMETER
11 FORMAT (1H+,113X,3HSPL,3X,5H(PWL)//30X,46Hl/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON,FM.1,13H METER RADIUS//)
DO 13 I=1,NF
   WRITE (6,12) NFI(I), (SLR(1,J), J=1,NM), AVSPL(I), PW(I)
12 FORMAT (1H ,11X,2X,18X,10HANGLE, DEC,45X,6HSIMPLE,2X,5HPOWER//46X,6HSOURCE,2X,5HLEVEL)
13 IF (MOD(I,3).EQ.0) WRITE (6,14)
14 FORMAT (1H )
15 FORMAT (1H )
16 IF (SU(I).LE.0.0) GO TO 17
17 CONTINUE
WRITE (6,19) "")
19 FORMAT (1H0,2X,8HDISTANCE,35X,31HSIDELINE PERCEIVED NOISE LEVELS//)
   DO 21 I=1,IS
      CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
   END
   DO 2 J=1,NM
      CALL ORSUM (SLR(1,J), NF, OASPL(J))
   END
DO 21 I=1,IS
 CALL FARDTA (SL, RSTD, NF, NB, NM, AI, 59.0, 70.0, RSTD, 0, SLR)
DO 2 J=1,NM
```
SUBROUTINE TBLOP (A, NF, NFIL, NM, NEG)
/CBLOP - TABLE OUTPUT/
* * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * UTILITY ROUTINE TO OUTPUT DATA ARRAY. * * * *
* A DATA ARRAY
* NF NUMBER OF FREQUENCY BANDS
* NFIL BAND CENTER FREQUENCIES
* NM NUMBER OF ANGLES
* NEG OUTPUT CONTROL. IF NEG = 0 ALL NEGATIVE
* VALUES IN ARRAY A WILL BE REPLACED WITH ZERO FOR
* EASE OF READING. IF NEG IS OTHER THAN ZERO, ARRAY
* IS UNAFFECTED.
*
* DIMENSION A(27,19)
DIMENSION NFIL(27)
IF (NEG.NE.0) GO TO 2
DO 1 J=1,NM
DO 1 I=1,NF
IF (A(I,J).LT.0.0) A(I,J)=0.0
1 CONTINUE
WRITE (6,3)
FORMAT (1H, BAND FREQUENCY)
DO 4 I=1,NF
WRITE (6,5) I,NFIL(I),A(I,J),J=1,NM
4 WRITE (6,1H,13,18,3X,19F6.1)
5 FORMAT (1H, I3, I8, 3X, 19F6.1)
WRITE (6,6)
6 FORMAT (/)
RETURN
END

SUBROUTINE TITLE (A,NCONF,RPM,PCS)
/TITLE - TITLE OUTPUT/
* * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * UTILITY ROUTINE TO OUTPUT ID INFORMATION. * * *
* A FOUR ID CARDS
* NCONF CONFIGURATION NUMBER
* RPM SPEED IN RPM
* PCS PERCENT SPEED
*
* * * * * * * * * * * * * * * * * * * * * * * * * * * * *

SUBROUTINE TITLE2
/TITLE2 - TITLE OUTPUT/
C ** UTILITY ROUTINE TO OUTPUT ID INFORMATION. **
C 
COMMON A(20,4,2),AI(19,2),NFIL(27,2),NCONF(2),RPM(2),PCS(2),
1 NR(2),NF(2),NM(2),DT(2)
DIMENSION SET(2),AIL(2),IFIL(2)
DATA SET(1),SET(2)/3HONE,3HTWO/
DO 1 K=1,2
J=NF(K)
IFIL(K)=NFIL(J,K)
J=NM(K)
AIL(K)=AI(J,K)
WRITE (6,2)
2 FORMAT (1H COMPARISON OF TWO DATA S
1ET S///)
DO 3 K=1,2
WRITE (6,4) SET(K),(A(I,1,K),I=1,20),(A(I,2,K),I=1,20),NCONF(K),PCS(K),
1S(K),RPM(K),(A(I,3,K),I=1,20),NFIL(K),PCS(K),A(1,4
2,K),I=1,20),NM(K),DT(K),AI(1,K),AIL(K)
3 FORMAT (1H DATA SET, A3, /1H ,20A4,5X,3BCONFIGURATION PERCENT
1 SPEED RPM/1H ,20A4,112,F20.1,F13.0/1H ,20A4,17,5H - 1/,11,18H
2OCTAVE BANDS FROM,15,3H TO,16,6H HERTZ/1H ,20A4,17,13H ANGLES EVER
3Y,F4.0,13H DEGREES FROM,F5.0,3H TO,F5.0///
RETURN
END

SUBROUTINE WDATA
/WDATA - WORKING DATA/
C ** READS ONE SET OF WORKING DATA FROM CARDS INTO STORAGE **
C ** COMMON BLOCK /WD/ **
C 
DIMENSION A(20,4)
WRITE (6,1)
1 FORMAT (1H1)
WRITE (6,2) A(I,J),J=1,20)
2 FORMAT (1H ,20A4,17X,16HCONFIGURATION NO,15)
WRITE (6,3) A(I,J),J=1,20),RPM
3 FORMAT (1H ,20A4,17X,7HSPEED =,F6.3,4H RPM)
WRITE (6,4) A(I,J),J=1,20),PCS
4 FORMAT (1H ,20A4,17X,15HPERCENT SPEED =,F6.1)
WRITE (6,2) A(I,J),J=1,20)
5 FORMAT (1H ,20A4,17X,16HCONFIGURATION NO,15)
WRITE (6,3) A(I,J),J=1,20)
WRITE (6,4) A(I,J),J=1,20)
WRITE (6,6)
6 FORMAT (1H)
RETURN
END

SUBROUTINE WDATA
/WDATA - WORKING DATA/
C ** READS ONE SET OF WORKING DATA FROM CARDS INTO STORAGE **
C ** COMMON BLOCK /WD/ **
C 
DIMENSION A(20,4)
WRITE (6,1)
1 FORMAT (1H1)
WRITE (6,2) A(I,J),J=1,20)
2 FORMAT (1H ,20A4,17X,16HCONFIGURATION NO,15)
WRITE (6,3) A(I,J),J=1,20),RPM
3 FORMAT (1H ,20A4,17X,7HSPEED =,F6.3,4H RPM)
WRITE (6,4) A(I,J),J=1,20),PCS
4 FORMAT (1H ,20A4,17X,15HPERCENT SPEED =,F6.1)
WRITE (6,2) A(I,J),J=1,20)
5 FORMAT (1H ,20A4,17X,16HCONFIGURATION NO,15)
WRITE (6,3) A(I,J),J=1,20)
WRITE (6,4) A(I,J),J=1,20)
WRITE (6,6)
6 FORMAT (1H)
RETURN
END
SUBROUTINE WODAG
/WODAG - WORKING DATA GENERATION/

C * VARIABLES RESULTING IN COMMON BLOCK /WD/
C *
C * A(20,4) FOUR CARDS OF ID (WORD LENGTH 4)
C * NCONF CONFIGURATION NUMBER
C * RPM SPEED IN RPM
C * PCS PERCENT SPEED
C * NF NUMBER OF FREQUENCY BANDS
C * NM NUMBER OF ANGLES
C * NB 1/NB-OCTAVE BANDS
C * PWL OVERALL ACOUSTIC POWER LEVEL
C * SUMN DECIBEL SUM OF NORMALIZED POWER SPECTRUM
C * PSM(27) NORMALIZED POWER SPECTRUM
C * DT ANGLE INCREMENT
C * AI(19) ANGLES
C * NFIL(27) BAND CENTER FREQUENCIES
C * DI(27,19) DIRECTIVITY INDEX
C *

DO 1 J=1,4
1 READ (5,2) (A(I,J),I=1,20)
FORM (20A4)
READ (5,3) NCONF,RPM,PCS,NF,NM,NB
FORMAT (14,2F8.1,3I3)
IF (NF.EQ.10) GO TO 5
READ (5,4) PWL,SUMN,(PSM(I),I=1,NF)
FORMAT (12F6.1/12X,10F6.1)
GO TO 7
READ (5,6) PWL,SUMN,(PSM(I),I=1,NF)
FORM (12F6.1)
READ (5,6) DT,(AI(J),J=1,NM)
DO 11 I=1,NF
IF (NM.EQ.10) GO TO 9
READ (5,8) NFIL(I),(DI(I,J),J=1,NM)
FORMAT (6X,I6,10F6.1/12X,10F6.1)
GO TO 11
READ (5,10) NFIL(I),(DI(I,J),J=1,NM)
FORM (6X,I6,10F6.1)
CONTINUE
RETURN
END
**VARIABLES NECESSARY IN COMMON BLOCK /WODA/**

**A(20,4)**: FOUR CARUS OF ID (WORD LENGTH 4)

**NCNF**: CONFIGURATION NUMBER

**RPM**: SPEED IN RPM

**PCS**: PERCENT SPEED

**SL(27,19)**: MEASURED ARRAY (TEST DAY SOUND PRESSURE LEVELS)

**T**: TEST TEMPERATURE (DEGREES FAHRENHEIT)

**RH**: TEST RELATIVE HUMIDITY

**BAR**: TEST BAROMETER (INCHES HG)

**AO**: FIRST MICROPHONE ANGLE

**DT**: MICROPHONE ANGLE INCREMENT

**R(19)**: MICROPHONE RADII

**NM**: NUMBER OF MICROPHONES

**NF**: NUMBER OF FREQUENCY BANDS

**NB**: KIND OF FRACTIONAL-OCTAVE BANDS (1 OR 3)

**RSTD**: STANDARD RADIUS FOR DATA LISTINGS

**SD(5)**: OPTIONAL SIDELINE DISTANCES FOR DATA EXTRAPOLATIONS

**DIMENSION BUF(27,19), TFA(27,19)**

**DIMENSION AI(19), AM(19)**

**DIMENSION B(27), C(27), D(27), E(27), NFIL(27), SLR(27)**

**DIMENSION DS(6)**

**INTEGER FREQ(27)**

**DATA FREQ/50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000,**

**1250, 1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, 10000, 12500, 16000,**

**20000/**

**DEFINE NUMBER OF SIDELINE DISTANCES**

**DO 1 I=1, 5**

**IF (SD(I).LE.0.0) GO TO 2**

**CONTINUE**

**NR=5**

**GO TO 3**

**CONTINUE**

**NR=I-1**

**CONTINUE**

**DEFINE BAND CENTER FREQUENCIES**

**DO 4 I=1, NF**

**J=I**

**IF (NB.EQ.1) J=3*I-1**

**NFIL(I)=FREQ(J)**

**DEFINE MICROPHONE ANGLES**

**DO 5 I=1, NM**

**AI(I)=AO+DT*FLOAT(I-1)**

**SIMPLY ADJUST TO CONSTANT RADIUS FOR REVIEW ONLY**

**DO 6 J=1, NM**

**DL=20.0*ALOG10(R(J)/RSTD)**

**DO 6 I=1, NF**

**SL(I,J)=SL(I,J)+DL**
C MEASURED ARRAY
C
7 WRITE (6,7)
8 FORMAT (1(H1)
9 DC 9 J=1,4,
10 WRITE (6,9) (A(I,J),I=1,20)
11 FORMAT (26X,20A4//)
12 WRITE (6,10) NCONF,RPM,PCS
13 FORMAT (16X,16HCONFIGURATION NO.15,10X,7HSPDI) =,F6.3,4H RPM,10X,1
14 HPERCENT SPEED =,F6.1//)
15 WRITE (6,11) T,RH,HAR
16 FORMAT (10X,17HTEST CONDITIONS -- 7X,13HTEMPERATURE =,F5.1,2H F,6X,
17 119HRELATIVE HUMIDITY =,F5.1,3H PC,6X,11HBAROMETER =,F6.2,6H IN HG/2/)
18 WRITE (6,12) RSTD
19 FORMAT (52X,27HMEASURED ARRAY//37X,41HMEASURED DATA SIMPLY ADJUSTED TO CONSTANT,F6.1,10H FT RADIUS//)
20 CALL ANGLE (AI,NM)
21 CALL UASPL (SL,NM,NF,B)
22 WRITE (6,13) (B(I),I=1,NM)
23 FORMAT (15H COMPUTED UASPL,19F6.1)
24 WRITE (6,14)
25 FORMAT (/)
26 CALL TBLOP (SL,NF,NFIL,NM,1)
27 FORMAT (48X,31HORIGINAL MICROPHONE RADII, FEET//15X,19F6.1)
C
C PAGE TWO
C TEST DAY ATMOSPHERIC ABSORPTION
C
29 CALL TITLE (A,NCONF,RPM,PCS)
30 DO 16 J=1,NM
31 CALL BASPAT (SL(1,J),RSTD,NF,MB,T,RH,B,RSTD,C)
32 DO 16 I=1,NF
33 BUF(I,J)=B(I)*R(J)/1000.0
34 SL(I,J)=SL(I,J)+BUF(I,J)
35 WRITE (6,17) T,RH
36 FORMAT (27X,7HTEST DAY EXCESS ATMOSPHERIC ATTENUATION//34X,62HADDITIONS TO UNADJUSTED MEASURE
37 3UMIDITY/46X,F10.0,2H F, 12X,F5.1,3H PC//)
38 CALL ANGLE (AI,NM)
39 CALL UASPL (SL,NM,NF,E)
40 WRITE (6,13) (E(I),I=1,NM)
41 WRITE (6,14)
42 CALL TUBL (SL,NF,NFIL,NM,1)
43 PAGE THREE
44 REFERRED ARRAY
C
45 CALL TITLE (A,NCONF,RPM,PCS)
46 WRITE (6,18) RSTD
47 FORMAT (52X,27HREFERRED ARRAY//38X,7HDATA AT,F6.1,42H
48 1 FT RADIUS WITH NO ATMOSPHERIC ATTENUATION//45X,40HFOR POWER AN D.
49 2RECTIVITY COMPUTATIONS)\\)
50 CALL ANGLE (AI,NM)
51 CALL UASPL (SL,NM,NF,E)
52 WRITE (6,13) (E(I),I=1,NM)
53 WRITE (6,14)
54 CALL TUBL (SL,NF,NFIL,NM,1)
C
C PAGE FOUR
C ACOUSTIC POWER COMPUTATIONS
COMPUTE TOTAL POWER

CALL POWER (E,RSTD,AI,NM,DT,T,BAR,PWL,W)
CALL AVSLR (E,AI,DT,NM,SLRD)

COMPUTE POWER SPECTRUM

DO 23 I=1,NF
19 DO 1 J=1,NM
18 R(J)=SL(I,J)
20 CALL POWER (B,RSTD,AI,NM,DT,T,BAR,PW,D)
21 C(I)=PW
22 CMAX=C(I)
23 CONTINUE
DO 25 I=1,NF
24 B(I)=C(I)-CMAX
CALL DBSUB (H,NF,SUM)
DO 26 I=1,NF
25 D(I)=SL(I,J)
26 CALL AVSLR (D,AI,NM,SLR(I))
27 CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,25) RSTD
28 WRITE (6,25) "COUSTIC POWER COMPUTATION"
29 WRITE (6,25) "NORMALIZED POWER SPECTRUM POWER SPECTRUM SOURCE SPL R =,F6.1,3H FT"
30 WRITE (6,25) "POWER SPECTRUM POWER SPECTRUM,5X,15HSUURCE SPL, R =,F6.1,3H FT"
31 WRITE (6,25) "OVERALL\ OVERALL"
32 WRITE (6,25) "TOTAL ACOUSTIC POWER/72X,3H FT"
33 WRITE (6,25) "TTS/1"

PUNCH HEADER AND POWER DATA

DO 31 J=1,4
30 PUNCH 32, (A(I,J),I=1,20)
31 FORMAT (20A4)
32 PUNCH 33, NCONF,RPM,PCS,NF,NM,NB
33 FORMAT (14,2F8.1,3I3)
34 IF (NF.EQ.10) GC TO 35
35 PUNCH 34, PWL,SUM,(B(I),I=1,NF)
36 FORMAT (12F6.1/(12X,10F6.1))
37 CONTINUE

NORMALIZED POWER SPECTRUM (GRAPH)

CALL TITLE (A,NCONF,RPM,PCS)
CALL GRAPH (B,NF)
CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,47)
FORMAT (43X,45XATMOSPHERIC ATTENUATION//35X,161XSTANDARD DAY EXCESS ATMOSPHERIC ATTENUATION PER THOUSAND FEET//)
CALL ANGLE (AI,NM)
CALL TBLQP (TFA,NF,NFIL,NM,1)

PAGE EIGHT
STANDARD DAY DATA ATMOSPHERIC ABSORPTION

CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,48) RSTD
FORMAT (16X,95XSTANDARD DAY DATA EXCESS ATMOSPHERIC ATTENUATION//26X,60XADJUSTMENTS TO REFERRED ARRAY TO OBTAIN STANDARD DAY DATA AT, F.0, 10H FT RADIUS 3//)
DO 49 J=1,NM
DO 49 I=1,NF
BUF(I,J)=TFA(I,J)*RSTD/1000.0
CALL ANGLE (AI,NM)
CALL TBLOP (BUF,NF,NFIL,NM,1)  

PAGE NINE
STANDARD DAY DATA

CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,50) RSTD
50 FORMAT (48X,33HSTANDARD DAY DATA//43X,7HDATA AT,F6.1,1.1,30HFT KADI US UN 59F, 70PC RH DAY//)
DO 51 J=1,NM
DO 51 I=1,NF
51 BUF(I,J)=SL(I,J)-BUF(I,J)
CALL ANGLE (AI,NM)
CALL OASPL (BUF,MM,NF,B)
WRITE (6,13) (B(I),I=1,NM)
WRITE (6,14)
CALL TBLOP (BUF,NF,NFIL,NM,1)
WRITE (6,14)
CALL ANGLE (AI,NM)
CALL OASPL (BUF,MM,NF,B)
WRITE (6,52) RSTD
52 FORMAT (44X,18HPERCEIVED NOISE ON,F8.1,17HFT RADIUS, PNDB//)
CALL ANGLE (AI,NM)
CALL APNDH (BUF,NH,NM,B)
WRITE (6,53) (B(I), I=1,NM)
53 FORMAT (15X.19F6.1)

C "PAGE TEN AND FOLLOWING"
SIDELINE EXTRAPOLATED DATA

DELETE ON-AXIS DATA

MM=NM
DO 54 J=1,MM
AM(J)=AI(J)
IF (AM(J).LT.0.0) GO TO 56
MM=MM-1
DO 55 J=1,MM
AM(J)=AM(J+1)
DO 55 I=1,NF
SL(I,J)=SL(I,J+1)
56 IF (AM(MM).LT.0.0) GO TO 57
MM=MM-1
CONTINUE
57
KK=NR+1
DO 58 I=2,KK
DO 58 DS(I)=DS(I-1)
DO 58 DS(I)=RSTD
DO 64 K=1,KN
CALL TITLE (A,NCONF,RPM,PCS)
WRITE (6,59) DS(K)
59 FORMAT (42X,52HSIDELINE EXTRAPOLATED DATA//23X,20HSTANDARD DAY DATA ON,70.59HFT SIDELINE, INCORPORATING 2G EXCESS ATMOSPHERIC ATTENUATION//)
CALL SIDELAT (MM,AM,RSTD,DS(K),B,C)
DO 60 J=1,MM
DO 60 I=1,NF
BUF(I,J)=SL(I,J)-R(J)-TFA(I,J)*C(J)/1000.0
CALL ANGLE (AM,MM)
CALL OASPL (BUF,MM,NF,B)
WRITE (6,13) (C(I),I=1,MM)
WRITE (6,14)
CALL TBLUP (BUF, NF, NFIL, MM, J)
WRITE (6, 14)
WRITE (6, 611) DS(1), DS(K), (B(I), I=1, MM)
61 FORMAT (30X, 35H INVERSE SQUARE LAW ATTENUATION FROM, F7.0, 14H FT RA
IDIUS TO, F7.0, 13H FT SIDELINE//15X, 19F6.1//)
WRITE (6, 14)
CALL ANPUB. (BUF, NB, NM, B)
WRITE (6, 62) DS(K)
62 FORMAT (45X, 18H RECEIVED NOISE ON, F7.0, 19H FT SIDELINE, PNDB//)
CALL ANGLE (AM, MM)
WRITE (6, 63) (B(I), I=1, MM)
63 FORMAT (15X, 19F6.1)
IF (NK.LE.0) GO TO 65
64 CONTINUE
65 WRITE (6, 7)
C
RETURN
END
REFERENCES


# TABLE I - SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**
**LEWIS RESEARCH CENTER**
**PROPULSION SYSTEMS ACOUSTICS BRANCH**

**SAMPLE NOISE DATA**

**CONFIGURATION NO.** 100  
**SPEED =** 1800 RPM  
**PERCENT SPEED =** 75.0

**TEST CONDITIONS**  
**TEMPERATURE =** 50.0°F  
**RELATIVE HUMIDITY =** 60.0%  
**BAROMETER =** 30.00 IN HG

**MEASURED ARRAY**

MEASURED DATA SIMPLY ADJUSTED TO CONSTANT 100.0 FT RADIUS

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<th>10.0</th>
<th>20.0</th>
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<td>55.0</td>
<td>51.0</td>
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<td>92.1</td>
<td>91.5</td>
<td>90.3</td>
<td>89.3</td>
<td>89.1</td>
<td>89.1</td>
<td>88.9</td>
<td>88.9</td>
<td>86.0</td>
<td>86.6</td>
<td>83.0</td>
<td>80.0</td>
<td>76.0</td>
<td>75.0</td>
<td>75.0</td>
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</table>

**PAN D FREQUENCY**

| Freq  | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   | 21   | 22   | 23   | 24   | 25   | 26   | 27   |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

**ORIGINAL MICROPHONE RADI, FEET**

<p>| Val | 100.0 | 104.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |</p>
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**Table I. Continued.** SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

**Configuration No. 100**
- Speed = 1800 RPM
- Percent Speed = 75.0

**Referred Array**
- Data at 100.0 ft radius with no atmospheric attenuation
  (FCR power and directivity computations)

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TOTAL ACOUSTIC POWER

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\[
\text{W} = 22.5 \text{ WATTS} \]
TABLE I. - Continued. SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
PROPULSION SYSTEMS ACOUSTICS BRANCH
SAMPLE NOISE DATA

NORMALIZED POWER SPECTRUM

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CONFIGURATION NO. 100
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**ATMOSPHERIC ATTENUATION**

**STANDARD DAY EXCESS ATMOSPHERIC ATTENUATION PER THOUSAND FEET**

**COMPLETED FROM REFERRED ARRAY CONSIDERING SPECTRUM SHAPES**

**CONFIGURATION NO. 192**

SPEED = 1000 RPM

PERCENT SPEED = 75.0

---

**TABLE I. - Continued.** SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG
TABLE I. - Continued. SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

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#### STANDARD DAY DATA

**DATA AT 100.0 FT RADIUS ON 59F, 70PC RH DAY**

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<td>73.4</td>
<td>74.0</td>
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**SIDELINE EXTRAPOLATED DATA**

**STANDARD DAY DATA EN**

**100+ FT SIDELINE, INCORPORATING EXCESS ATMOSPHERIC ATTENUATION**

**SAMPLE ACISF DATA**

**INVERSE SQUARE LAW ATTENUATION FROM 100+ FT RADIUS TO 100+ FT SIDELINE**

**PERCEIVED NOISE ON 100+ FT SIDELINE, PMDB**

**ANGLER**

10°  20°  30°  40°  50°  60°  70°  80°  90°  100°  110°  120°  130°  140°  150°  160°

80+  55+  59.5  103+  102.5  102.0  102.4  106.0  106.9  107+  106.5  103+  98+  90+  90+
## TABLE I - Continued. SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

<table>
<thead>
<tr>
<th>ANGLE</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
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<th>110°</th>
<th>120°</th>
<th>130°</th>
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<tbody>
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**SIQUELE EXTRAPOLATED DATA**

<table>
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<th>STANDRD SAT DATA CTN</th>
<th>370 FT SIDELINE, INCORPORATING EXCESS ATMOSPHERIC ATTENUATION</th>
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<tr>
<td>WAVE FREQUENCY</td>
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**INVERSE SQUARE LAW ATTENUATION FROM 100 FT RADIUS TO 370 FT SIDELINE**

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<th>150°</th>
<th>160°</th>
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</table>

**CONFIGURATION NO 193**

- SPEED = 1800 RPM
- PERCENT SPEED = 75.0

(continued on the next page)
TABLE I. - Concluded. SAMPLE OUTPUT FROM WORKING DATA GENERATION SUBROUTINE WODAG

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<th>150°</th>
<th>160°</th>
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SIDELINE EXTRAPOLATED DATA

STANDARD LAY DATA ON 1000 FT SIDELINE, INCORPORATING EXCESS ATMOSPHERIC ATTENUATION

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<td>65.0</td>
<td>66.2</td>
<td>60.0</td>
<td>60.2</td>
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</tbody>
</table>

FREQUENCY

| FREQUENCY | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ANGLE | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° | 100° | 110° | 120° | 130° | 140° | 150° | 160° |
| CEMEFED DATA | 44.1 | 53.9 | 59.4 | 63.6 | 64.8 | 66.0 | 67.0 | 68.0 | 68.1 | 67.8 | 66.5 | 65.9 | 65.0 | 66.2 | 60.0 | 60.2 |

INVERSE SQUARE LAW ATTENUATION FROM 1000 FT RADIUS TO 10000 FT SIDELINE

| ANGLE | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° | 100° | 110° | 120° | 130° | 140° | 150° |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CEMEFED DATA | 44.1 | 53.9 | 59.4 | 63.6 | 64.8 | 66.0 | 67.0 | 68.0 | 68.1 | 67.8 | 66.5 | 65.9 | 65.0 | 66.2 | 60.0 | 60.2 |

PERCEIVED NOISE ON 10000 FT SIDELINE, PNDB

<p>| ANGLE | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° | 100° | 110° | 120° | 130° | 140° | 150° |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CEMEFED DATA | 44.1 | 53.9 | 59.4 | 63.6 | 64.8 | 66.0 | 67.0 | 68.0 | 68.1 | 67.8 | 66.5 | 65.9 | 65.0 | 66.2 | 60.0 | 60.2 |</p>
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</table>

1/3-CTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS

Data adjusted to standard day cf 15 degrees C, 70 percent relative humidity

SPL re .00002 N/SQ M
PWL re .1 PICOWATT

Table II - Sample Output from Subroutine Table

<table>
<thead>
<tr>
<th>DISTANCE</th>
<th>SIDELINE PERCEIVED NOISE LEVELS</th>
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<td>112.8 M</td>
<td>94.3 80.1 85.3 89.3 89.2 88.9 88.6 88.9 92.7 93.0 93.3 93.2 52.4 88.6 83.1 74.8</td>
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<tr>
<td>304.8 M</td>
<td>89.5 85.0 71.7 76.4 76.9 76.9 76.6 76.2 79.7 79.9 80.3 79.8 78.6 74.3 69.2 60.3</td>
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### Table III - Sample Output from Subroutine DADIFF

#### Comparison of Two Data Sets

**DATA SET ONE**
- National Aeronautics and Space Administration
- Lewis Research Center
- Propulsion Systems Acoustics Branch
- Sample Noise Data

**DATA SET TWO**
- National Aeronautics and Space Administration
- Lewis Research Center
- Propulsion Systems Acoustics Branch
- Sample Noise Data, Second Set

#### Power Level Differences
(Data Set Two Minus Data Set One)

<table>
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<th>Total Power</th>
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<th>REAR QUADRANT</th>
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</table>

**Configuration**
- Percent Speed: 75.0, 100.0
- RPM: 1000, 27 - 1/2 octave bands from 50 to 20000 Hz
- 16 angles every 10 degrees from 10 to 160.

**Configuration**
- Percent Speed: 50.0, 120.0
- RPM: 27 - 1/3 octave bands from 50 to 20000 Hz
- 16 angles every 10 degrees from 10 to 160.
| ANGLE  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| OVERALL | -6.2 | -5.6 | -6.5 | -6.6 | -7.3 | -9.1 | -11.4 | -11.5 | -12.5 | -12.3 | -11.5 | -16.5 | -16.5 | -12.4 | -12.8 |
| BAND FREQUENCY | | | | | | | | | | | | | | | | |
| 1 | 50 | -13.1 | -12.4 | -10.5 | -11.2 | -13.6 | -11.7 | -11.5 | -12.4 | -10.2 | -11.0 | -11.5 | -6.6 | -11.4 | -12.2 | -13.7 | -14.2 |
| 2 | 63 | -9.3 | -16.6 | -11.1 | -10.1 | -10.8 | -10.3 | -11.0 | -10.9 | -10.4 | -9.1 | -11.2 | -11.6 | -11.5 | -11.5 | -11.5 |
| 3 | 80 | -10.3 | -16.6 | -11.1 | -10.7 | -16.8 | -10.6 | -11.1 | -10.8 | -11.3 | -11.6 | -12.4 | -11.4 | -12.8 | -13.6 | -15.5 | -15.9 |
| 4 | 100 | -11.2 | -16.7 | -12.5 | -14.3 | -12.4 | -11.7 | -12.9 | -12.6 | -10.7 | -12.9 | -12.2 | -12.6 | -13.4 | -15.1 | -15.2 | -14.9 |
| 5 | 125 | -10.2 | -6.7 | -8.8 | -10.1 | -5.8 | -11.1 | -10.8 | -12.2 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 |
| 6 | 150 | -16.5 | -9.8 | -10.2 | -11.5 | -12.7 | -11.8 | -11.6 | -11.8 | -12.3 | -12.1 | -12.4 | -12.6 | -13.6 | -14.4 | -14.5 | -14.3 |
| 7 | 200 | -9.4 | -5.8 | -11.4 | -11.4 | -11.4 | -11.6 | -11.9 | -12.2 | -12.0 | -12.4 | -12.7 | -12.7 | -15.1 | -14.7 | -14.3 |
| 8 | 250 | -9.0 | -8.3 | -9.4 | -10.1 | -10.1 | -11.3 | -11.8 | -11.6 | -11.8 | -12.1 | -12.6 | -13.2 | -14.7 | -14.5 | -14.3 |
| 9 | 315 | -7.8 | -7.1 | -8.7 | -10.3 | -10.1 | -11.5 | -10.9 | -11.5 | -11.9 | -12.4 | -12.1 | -12.6 | -14.4 | -14.5 | -14.3 |
| 10 | 400 | -5.5 | -5.6 | -7.6 | -8.8 | -9.5 | -11.1 | -11.6 | -11.8 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 | -11.5 |
| 11 | 500 | -6.3 | -7.1 | -7.3 | -8.5 | -10.6 | -10.4 | -11.0 | -10.8 | -11.6 | -11.4 | -11.4 | -11.5 | -12.3 | -13.1 | -13.7 | -12.8 |
| 12 | 630 | -3.0 | -4.0 | -5.6 | -8.3 | -6.3 | -10.3 | -11.2 | -11.8 | -11.5 | -10.4 | -11.2 | -11.6 | -11.6 | -11.6 | -11.6 | -12.5 |
| 13 | 800 | -4.7 | -4.3 | -6.4 | -5.5 | -8.5 | -9.3 | -11.2 | -9.5 | -9.8 | -9.1 | -5.6 | -10.1 | -11.3 | -14.7 | -14.5 | -14.3 |
| 14 | 1000 | -2.2 | -1.6 | -3.5 | -4.1 | -8.9 | -7.8 | -9.5 | -7.3 | -7.1 | -6.1 | -6.5 | -6.1 | -5.6 | -5.5 | -5.5 | -7.1 |
| 15 | 1250 | -6.3 | -1.1 | -0.7 | -3.1 | -3.9 | -5.7 | -5.5 | -5.1 | -4.0 | -3.6 | -3.5 | -3.4 | -5.5 | -5.5 | -7.1 | -7.1 |
| 16 | 1600 | 0.2 | 1.7 | 1.4 | 0.4 | -0.8 | -2.6 | -3.6 | -3.7 | -4.2 | -3.5 | -2.9 | -3.6 | -2.6 | -2.6 | -5.6 | -5.3 |
| 17 | 2000 | -10.4 | -11.0 | -11.4 | -12.7 | -12.7 | -14.0 | -12.9 | -9.5 | -11.6 | -8.5 | -11.4 | -8.1 | -6.2 | -4.5 | -6.6 | -6.4 |
| 18 | 2500 | -0.6 | -0.4 | -1.6 | -1.1 | -2.3 | -3.8 | -4.6 | -3.6 | -2.6 | -2.4 | -2.1 | -3.1 | -1.2 | -3.1 | -3.6 |
| 19 | 3150 | 0.6 | 0.7 | -0.4 | -1.0 | -1.5 | -3.7 | -5.5 | -5.4 | -5.1 | -4.1 | -5.1 | -4.5 | -2.2 | -1.2 | -2.2 | -4.6 |
| 20 | 4000 | -3.5 | -2.7 | -3.3 | -3.7 | -4.5 | -5.9 | -9.8 | -9.0 | -10.7 | -11.7 | -5.5 | -6.6 | -6.3 | -8.4 | -6.7 | -10.2 |
| 21 | 5000 | -2.9 | -2.7 | -3.1 | -2.5 | -3.0 | -5.1 | -8.1 | -8.2 | -8.4 | -8.5 | -7.5 | -6.5 | -7.2 | -6.7 | -7.9 | -8.2 |
| 22 | 6300 | -4.6 | -3.5 | -4.5 | -4.7 | -4.6 | -7.0 | -11.2 | -12.3 | -13.5 | -11.7 | -11.6 | -10.7 | -7.7 | -6.8 | -10.2 |
| 23 | 8000 | -5.8 | -4.5 | -4.9 | -4.2 | -5.6 | -8.3 | -13.3 | -14.2 | -14.3 | -15.6 | -12.8 | -10.3 | -11.3 | -9.8 | -10.6 | -11.6 |
| 24 | 10000 | -7.3 | -5.5 | -5.6 | -5.8 | -6.6 | -9.8 | -14.0 | -15.9 | -16.2 | -16.5 | -16.6 | -16.4 | -14.4 | -13.2 | -13.7 | -14.3 |
| 25 | 12500 | -8.6 | -7.2 | -7.5 | -6.3 | -8.5 | -11.1 | -13.3 | -17.9 | -17.9 | -17.6 | -17.2 | -16.2 | -15.2 | -15.2 | -16.1 |
| 26 | 16000 | -9.8 | -9.1 | -9.5 | -10.6 | -10.2 | -13.7 | -13.6 | -20.9 | -21.6 | -20.4 | -21.2 | -21.2 | -16.5 | -17.5 | -17.5 | -18.5 |
| 27 | 20000 | -11.9 | -11.8 | -12.3 | -12.6 | -13.2 | -16.8 | -15.6 | -24.4 | -24.6 | -23.2 | -23.7 | -22.6 | -22.1 | -21.6 | -22.8 |
TABLE III. - Concluded. SAMPLE OUTPUT FROM SUBROUTINE DADIFF

COMPARISON OF TWO DATA SETS

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<th>PERCENT SPEED</th>
<th>RPM</th>
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PERCEIVED, AND TONE-CORRECTED PERCEIVED NOISE LEVELS AND DIFFERENCES ALONG SIDELINES

59.0 F, 70.0 PERCENT RH

**30 FT SIDELINE**

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**130 FT SIDELINE**

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### TABLE IV. LISTING OF TYPICAL SET OF WORKING DATA

|       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       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... (Table text continues with numerical data entries)
Figure 1. - Major elements of data handling system.
Figure 2. - Geometry of enclosing sphere for far-field acoustic measurements, showing elemental areas without ground plane.
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—National Aeronautics and Space Act of 1958

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