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NOISE IMPACT ASSESSMENT MANUAL

FOR

SELECTED TRANSPORTATION SOURCES

PRELIMINARY DRAFT

FOR EPA REVIEW ONLY

Office of Noise Abatement and Control
Office of Air and Waste Management
U.S. Environmental Protection Agency
Washington, D.C. 20460

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NOISE IMPACT ASSESSMENT MANUAL
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INTRODUCTION

This manual is designed for persons who have little or no background in environmental noise pollution and yet have a need to estimate the noise impact from sources such as highway traffic, railroad line operations, and aircraft flight operations. Such persons might include government officials as well as members of the private sector who are involved in environmental planning, assessment and enforcement activities. The materials needed to make these noise impact assessments are arranged in this manual in the form of tables, nomographs, and curves, so that a mathematical treatment of the subject matter is deliberately avoided. References are included for those readers who want more background information or who require methods which predict noise levels more accurately.

DECIBEL ADDITION

The magnitude of a sound is measured in decibels (dB). Table 1 shows a range of decibel levels associated with everyday sound sources. Because decibels are based upon a logarithmic scale, known decibel levels of separate sound sources cannot be added in the usual way. For example, suppose the sound intensity from source A is 80 dB and the sound intensity from source B is also 80 dB. When sources A and B are operating simultaneously, the resulting sound is not 160 dB, but rather 83 dB.

TABLE 1 - Common sounds and their dBA levels

Source	dBA
Rocket launching pad	180
Jet plane	140
Gunshot blast	140
Riveting steel tank	130
Automobile horn	120
Sandblasting	112
Woodworking shop	100
Punch press	100
Pneumatic drill	100
Boiler shop	100
Hydraulic press	100
Can manufacturing plant	100
Subway	90
Average factory	80-90
Computer card verifier	85
Noisy restaurant	80
Office tabulator	80
Busy traffic	75
Conversational speech	66
Average home	50
Quiet office	40
Soft whisper	30

Figure 1 provides a chart for combining sound sources two at a time. The horizontal scale represents the difference in decibels between the two levels to be added, while the vertical scale is the decibel increment which is added to the higher level of the two original levels. In the above case, the difference between source A and B is zero. From Figure 1, add 3.0 dB to the higher value, obtaining 83 dB.

EXAMPLE

Calculate the overall decibel level for the following intensity levels associated with each source:

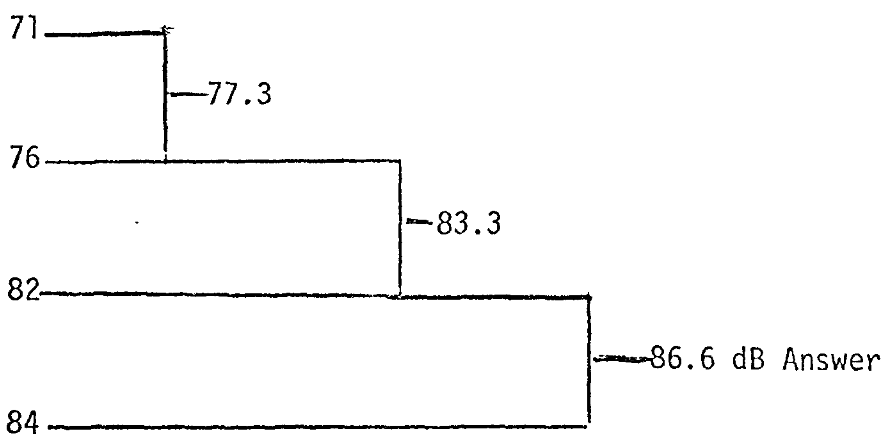
Source A - 82 dB

Source B - 76 dB

Source C - 84 dB

Source D - 71 dB

The levels are first arranged in ascending order before combining them two at a time using Figure 1.



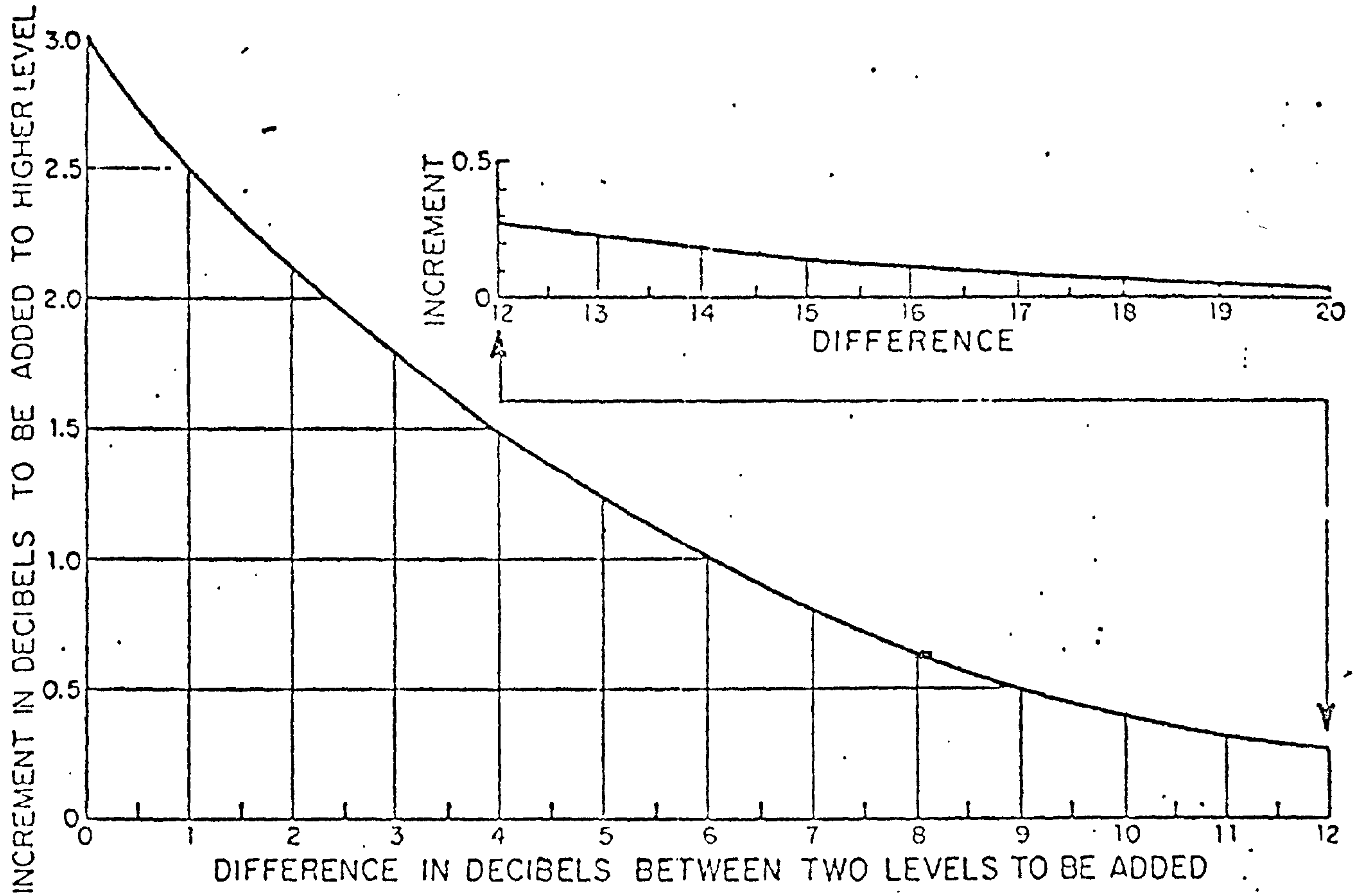


FIGURE 1. CHART FOR COMBINING SOUND LEVELS BY "DECIBEL ADDITION"

The 71 dB and 76 dB levels are combined to produce 77.3 dB from Figure 1. Now, 77.3 dB is combined with 82 dB to yeild 83.3 dB. Finally, 83.3 dB is added to 84 dB to yield 86.6 dB as the overall dB level.

FREQUENCY

It is known that human hearing is sensitive to the frequency of a sound. Because of this hearing characteristic, sound measuring equipment incorporate devices which filter certain frequencies in approximately the same fashion as the ear. The A-weighting network found on most sound level meters is such a device. Sounds measured in this manner are referenced as dBA rather than simply dB. Most federal noise regulations and local noise ordinances express allowable noise limits in terms of dBA levels.

SOUND DESCRIPTORS

While the basic measurements of sounds include frequency and intensity, the time variation of the sound intensity is normally required for community noise measurements. This is due to the wide fluctuation in the sound intensity in most environments. As a truck passes by a quiet street, the sound level may rise by 30 to 40 dB above the ambient level for a few seconds. To add this temporal characteristic of typical noise environments, different noise measurement methods have been developed over the years. One such method is the energy average equivalent sound level. This method is described below in simple terms and is used as the basic descriptor in this manual. More detailed mathematical definitions may be found elsewhere.[1,2]

DEFINITIONS

Equivalent Sound Level (Leq) - This is the level of a constant sound which, in a given situation and time period, has the same sound energy as does a time-varying sound. The symbol Leq is used for the equivalent sound level. Some common time periods for measuring Leq's include one hour, eight hours, and 24 hours represented as Leq(1), Leq(8), and Leq(24), respectively.

Sound Exposure Level - This is the level of sound accumulated over a given time interval or event and the symbol SEL is used. In contrast to Leq, which represents the average energy level, SEL represents the accumulation of sound energy. Therefore, SEL is always increasing up to the end of the event. SEL is frequently used in measuring the noise from a moving source, such as a airplane taking off or landing.

Day-Night Average Sound Level (Ldn) - This is the Leq(24) computed after 10 dB has been added to the nighttime levels (10 p.m. to 7 a.m.) The symbol Ldn is used. The 10 dB nighttime penalty is incorporated in the Ldn since noise can be more intrusive at night.

The Leq, SEL, and Ldn are the noise descriptors used in this manual. In particular, the Leq and Ldn are cumulative noise descriptors which have been adopted by EPA as appropriate for describing environmental noise.[1]

HIGHWAY TRAFFIC NOISE PREDICTOR

The current methodology [3,4,5] for predicting highway traffic noise levels employs a computer program to account for common highway complexities, such as, roadway gradients, pavement characteristics, roadway curves, ramps, depressed or elevated roadway sections, and barriers. By taking these and other factors into account, the computer program provides predicted sound levels to within ± 2 dBA of actual measurements.[5] A short method which uses only a nomograph rather than a computer is used in this manual and provides a conservative estimate of the highway noise. The extent of the over-prediction by the short method may vary from zero to a few decibels, depending on the complexity of the real highway relative to the short method model assumptions.[5]

Figure 2 shows a roadway and a residential development. The observer is located at point D. Distance DC is the perpendicular distance to the center line of the roadway. In the short method traffic is assumed to be freely flowing on a flat straight roadway with no obstructions between the observer and the roadway. In addition, the roadway is assumed to extend in both directions a distance which is at least four times the perpendicular distance from the observer to the roadway (distances AC and BC must be four times distance DC). If these conditions do not exist in any particular situation, corrections must be applied to the final computed sound level (see Appendices).

The noise emitted from the traffic is viewed in terms of three source categories which are defined as follows:

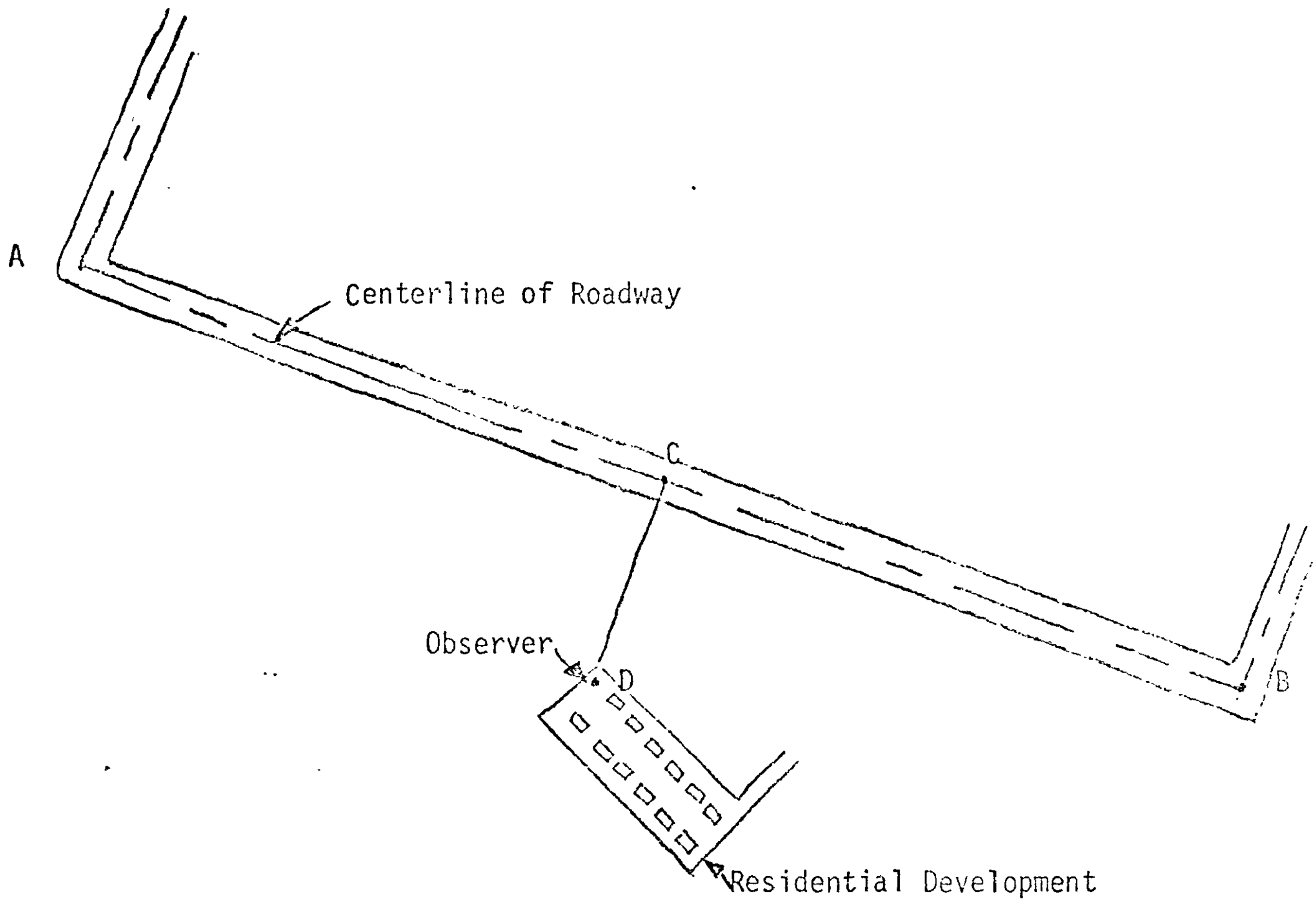


Figure 2 - Map showing Roadway and Observer

Automobiles: Two axle, four wheel vehicles including light trucks, such as a panel truck.

Medium Trucks: Gasoline-powered two axle, six wheel vehicles, such as a city truck, and busses.

Heavy Trucks: Diesel-powered, three or more axle vehicles, such as a tractor trailer.

Required Information

Obtain from the Highway Department the following information:

1. The volume flow for each of the above source categories during the busiest hour of the day.* The symbol V represents the number of vehicles per hour (veh/hr).

2. Determine the average speed, S, in miles per hour (mph) for each source category.

3. Select the distance, DC, in feet for each observation point of interest.

Nomograph Procedure

Figure 3 shows the nomograph which is used to estimate the Leq level in dBA in the following manner:

1. Draw a line from the pivot point at the left end through the heavy truck average speed in mph to intersect at a point on line A.

2. Draw a line from this point on line A to the heavy truck vehicle volume in veh/hr. This produces an intersecting point on line B.

*For predicting noise impact from proposed roadways, the design hourly volume should be used.

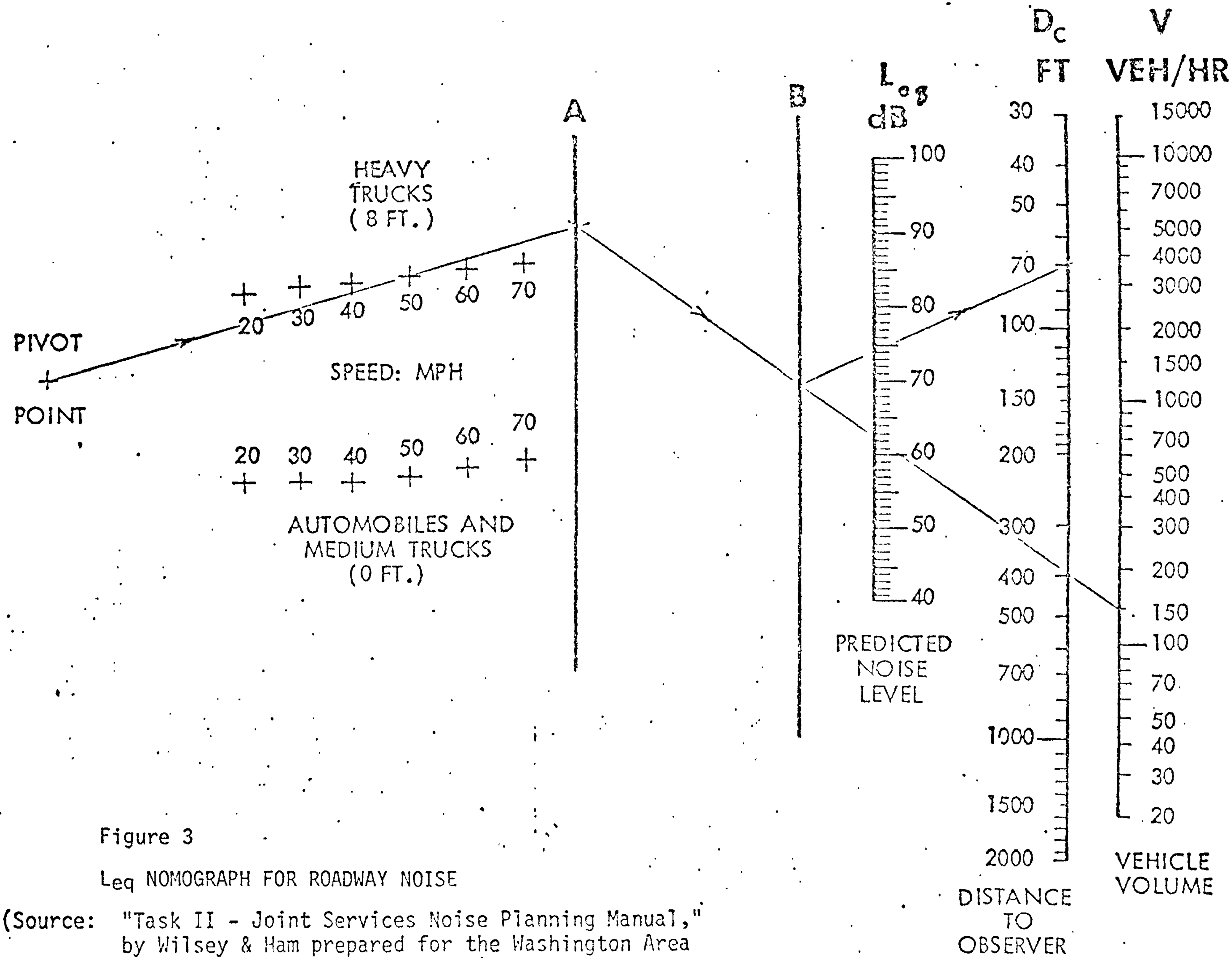


Figure 3

L_{eq} NOMOGRAPH FOR ROADWAY NOISE

(Source: "Task II - Joint Services Noise Planning Manual," by Wilsey & Ham prepared for the Washington Area Procurement Center, Nov. 1974.)

3. Draw a line from the point on line B to the distance to observer, DC. This line intersects the Leq scale which approximates the Leq level during the busiest hour due to the heavy truck traffic.

4. Repeat steps 1, 2, and 3 for the information on automobile traffic. However, in step 1 draw the line from the pivot point through the appropriate lower set of crosses associated with the average speed of the automobiles.

5. Multiply the medium truck volume flow by 10 to account for the inherent noisiness of these vehicles in comparison with automobile noise. Having this adjusted vehicle volume flow, repeat step 4. (Should the speed limit for automobiles and medium trucks be the same, steps 4 and 5 may be combined into one step. Simply add the flow volume for automobiles to the adjusted medium truck flow volume and follow step 4 to account for both sources simultaneously.)

6. Having the decibel values due to the separate noise sources, add them using decibel addition (Figure 1) to obtain the Leq associated with the busiest hour of the day.

Example

Calculate the Leq value for the following traffic data which correspond to the busiest hour of the day. Assume DC equals 200 ft.

Vehicle Category	Volume V (veh/hr)	Adjusted V (veh/hr)	Speed S (mph)	Distance DC (ft)	Leq (dBA)
Heavy truck	150	150	40	200	68
Automobile	4000	4000	50	200	64
Medium truck	200	2000	40	200	59

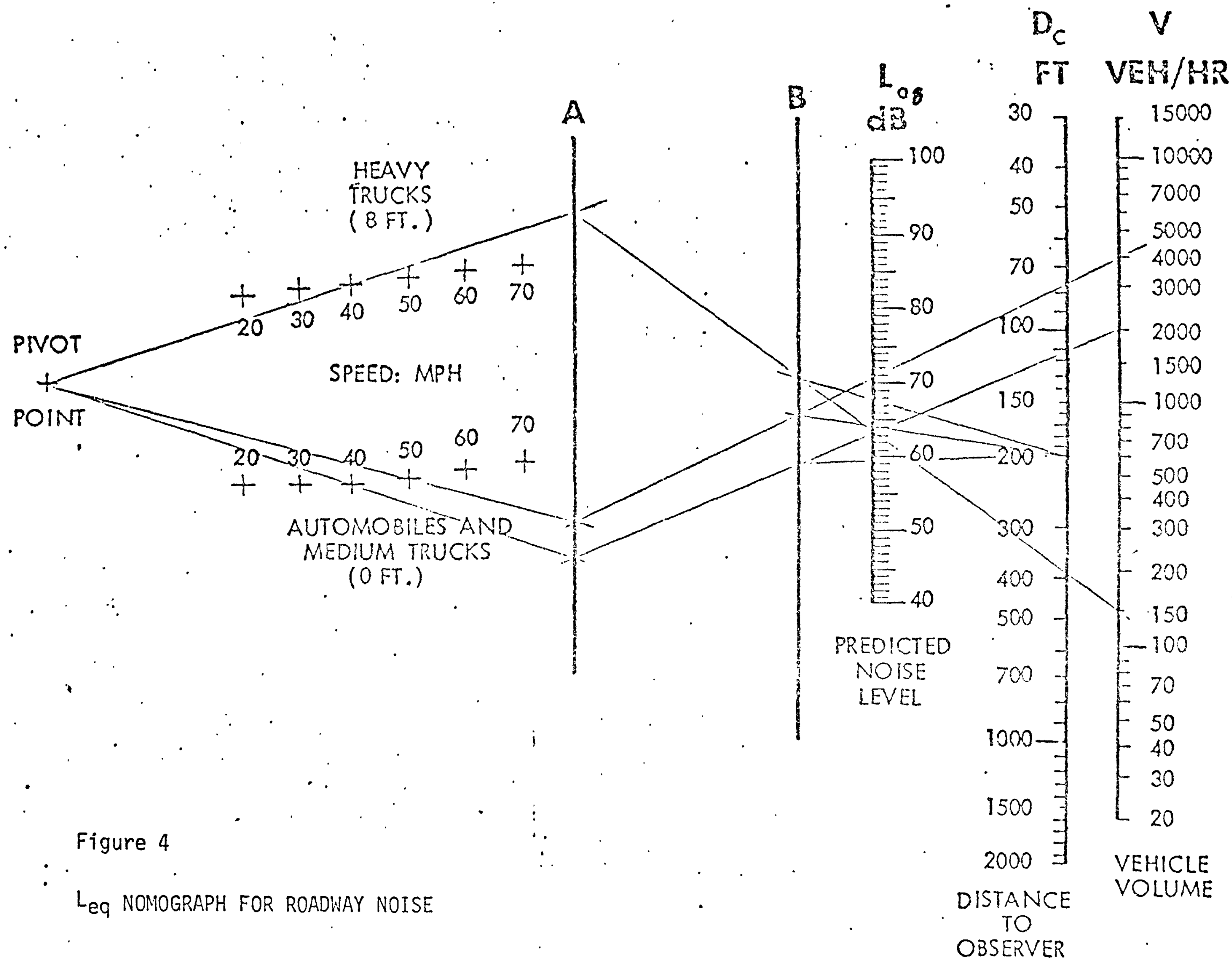
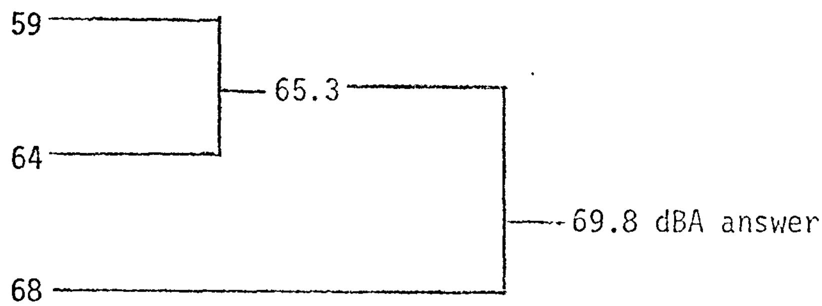


Figure 4

L_{eq} NOMOGRAPH FOR ROADWAY NOISE

Note that the third column incorporates the multiple factor of ten for medium truck volume flow. The Leq values listed in column 6 are obtained from the marked-up nomograph in Figure 4.

These Leq levels are now added, with the aid of Figure 1 as follows:



Noise Contours

To plot the Leq contours for the area near a highway, proceed as follows:

1. At any distance DC from the highway centerline, compute the Leq by the method already described.

2. Plot this point on Figure 5 (Leq vs. DC) and through this point draw a line parallel to the heavy dashed lines.

3. On the vertical axis, locate the noise level valve for each contour desired, move horizontally to the constructed line and then vertically down to the horizontal axis to determine the corresponding distance DC.

4. On a map or scale drawing of the roadway, draw the contours parallel to the roadway at the specified distances measured perpendicularly from the roadway centerline.

Example

Plot the 75, 70, 65, and 60 dBA contours for the highway noise example previously considered.

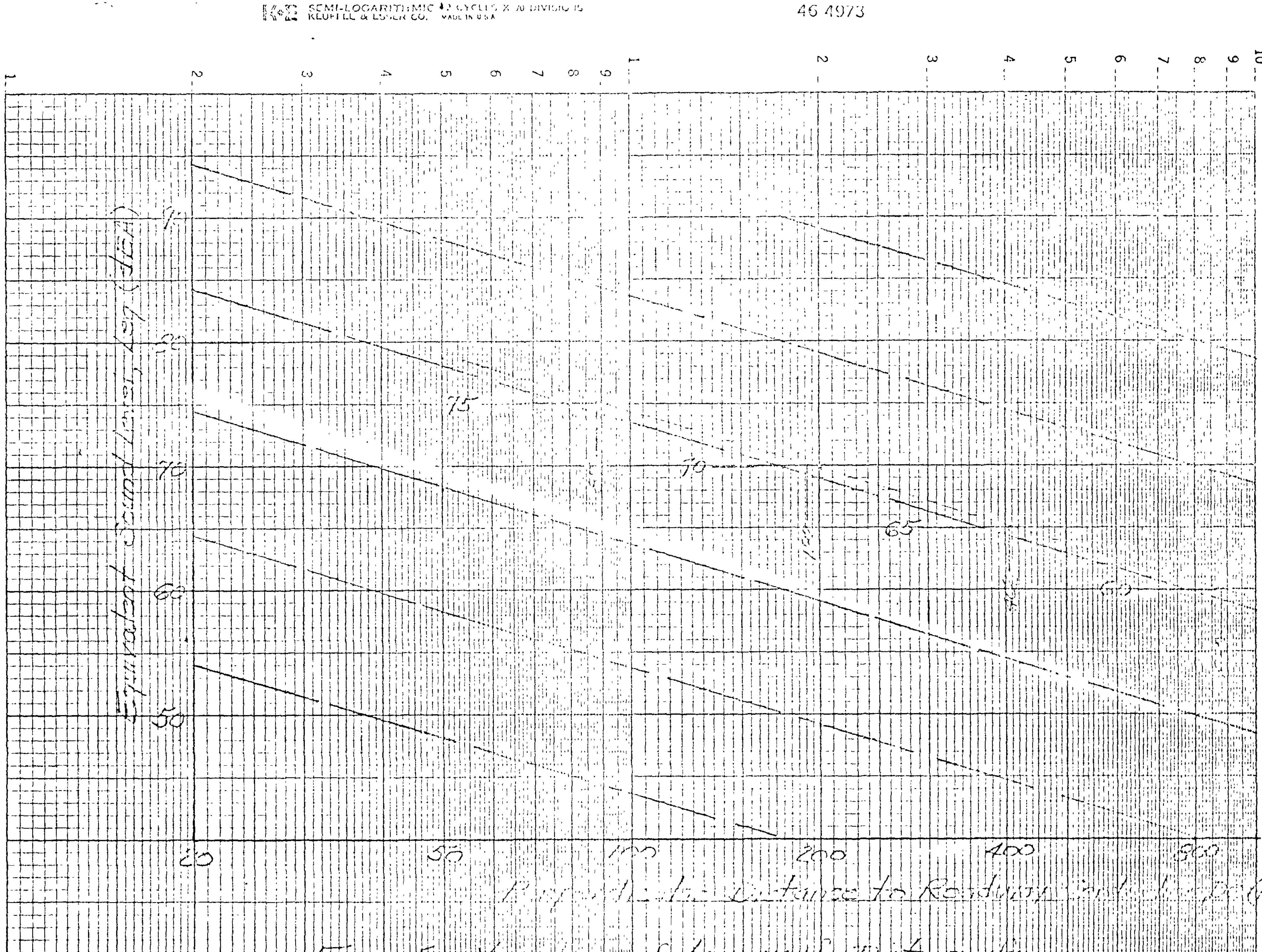


Figure 5. Variation of Leq with Distance from Roadway Centerline

It was determined that Leq was equal to 69.8 dBA when DC was 200 ft., so this point is plotted on Figure 5. (Shown with an X). Through this point a line is drawn parallel to the heavy dashed lines. Now the distances DC corresponding to the 75, 70, 65, and 60 dBA levels are determined to be 87, 182, 402, and 880 ft. respectively. On the site plan of the highway, Figure 6, construct a perpendicular to the highway centerline. Lay off the distances DC to scale along this perpendicular as shown. Now construct the contours through these points and parallel to the highway.

Ldn

In order to approximate the Ldn values from the computed busiest hour Leq levels, obtain the percentage of day and nighttime percentages of the 24-hour traffic volume and apply correction values from Table 2. The Table gives corrections to apply to Leq for various percentages of daytime and nighttime traffic. As an example, suppose the Leq is 65 dBA and 85% of the traffic occurs during daytime hours. From the Table, $\Delta = +1$ dB. Therefore Ldn $\hat{=}$ 65 + 1 = 66 dBA.

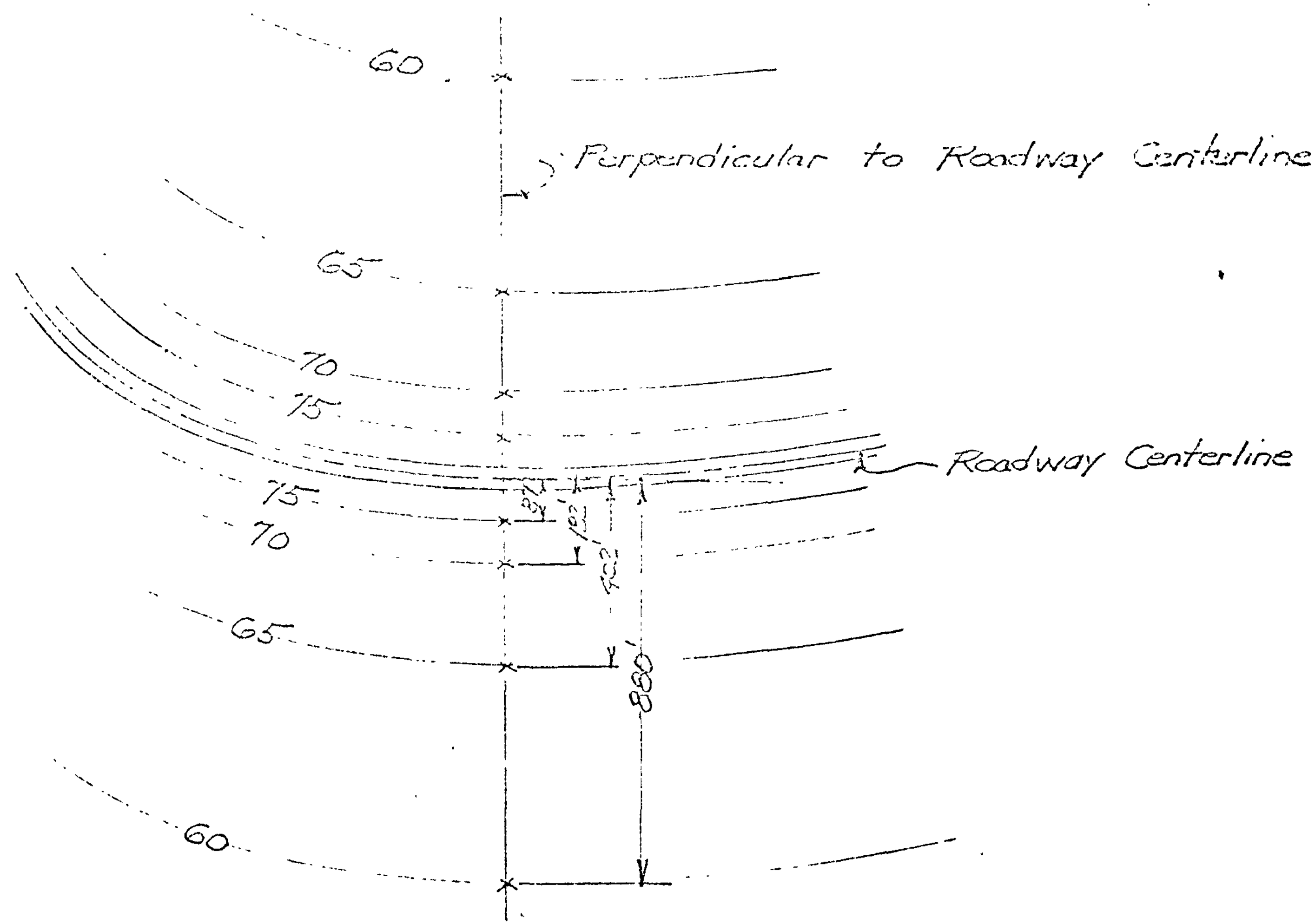


Figure 6. Leq Contour Construction for Highway Noise

TABLE 2 - Correction values Δ to be added to Leq to obtain Ldn. (Source: "Design Guide for Highway Noise Prediction and Control," Bolt, Beranek and Newman Report 2739, Vol. 1, pg. D-17)

Percentage of traffic during daytime hours	Percentage of traffic during nighttime hours	Correction value Δ (dB)
62.5	37.5	+ 3
75	25	+ 2
85	15	+ 1
90	10	0
95	5	-1
100	0	-3

RAILROAD LINE NOISE PREDICTOR

Recent studies[6,7,8] show that cumulative noise exposure levels may be approximated for both railroad line operations and railroad yard operations. Due to the complexities involved in railroad yard operations, only railroad line operations are considered in this manual.

The noise generated by line operations consists of two major sources: the noise generated by the locomotive and the noise generated by the passing cars. Analysis of field measurements shows that the locomotive noise does not vary appreciably with speed, while car noise is directly related to both the train speed (the faster the speed the higher the noise) and the train pass-by time (the longer the pass-by time the higher the noise). Since faster trains have lower pass-by times, the two components of the car noise tend to compensate each other. Therefore, the train speed may be neglected when estimating railroad line noise.

Required Information

The railroad line noise predictor requires the following:

1. Determine the number of daytime (N_d) and/or nighttime (N_n) train operations. Daytime operations are from 7:00 a.m. to 10:00 p.m. and nighttime operations are from 10:00 p.m. to 7:00 a.m. N_d and/or N_n should be established for typical day, and may represent the mean daily level of activity measured over a normal week.

2. Establish the distance from the track centerline to where the estimation will be made.

3. Identify those variables listed in Table 3 which affect the noise levels.

Procedure

Figure 7 is the graph which is used to estimate the noise levels in the following manner:

1. Calculate the equivalent number of operations N for which the Equivalent Sound Level (Leq) is sought.

(a) For Leq (day), N = Nd

(b) For Leq (night), N = Nn

(c) For Leq (24), N = Nd + Nr

(d) For Ldn, N = Nd + 10 Nr

2. Having N, enter Figure 8 at the prescribed distance and proceed vertically to the appropriate N contour. Move across horizontally and read the Leq level.

3. If necessary, enter Table 3 to add corrections to the Leq level obtained in step 2. Note that in the case of multiple occurrences of the variables shown in the table, only the larger of the adjustment values should be used.

Example

Calculate the Ldn level at distances of 100, 200 and 1000 ft from the track centerline for the typical 24-hour train operations shown below:

Type	Direction	N_D	N_N
Freight	Eastbound	10	6
Passenger	Eastbound	6	3
Freight	Westbound	8	5
Passenger	Westbound	6	3
	Total	30	17

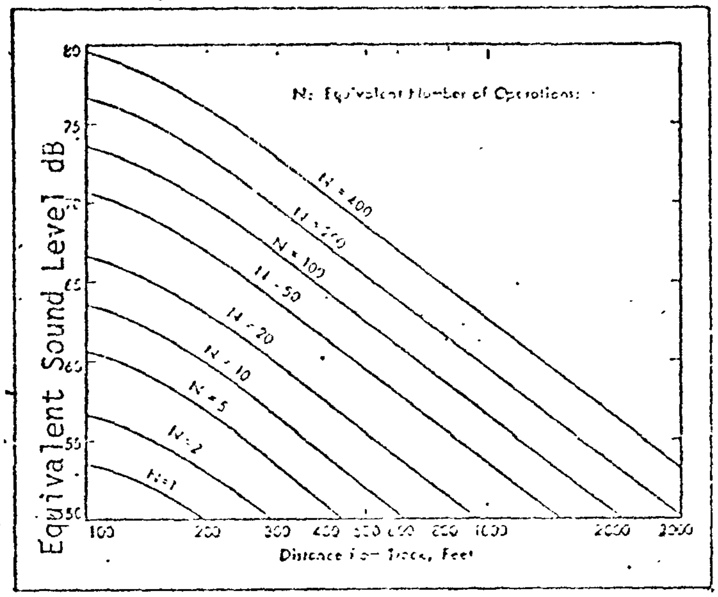


FIGURE 7 Noise Levels for Railroad Line Operations

TABLE 3 - Adjustments to Ldn Noise Contours

Variables Affecting Noise Output	Corrections to Desired Ldn Value, dB
1. Passenger trains only (If combination of passenger and freight - assume all freight)	-1
2. Presence of helper engines:	
a. Level grade or descending grade	0
b. Ascending grade	+2
3. Mainline welded or jointed track	0
4. Low speed classified jointed track	+4
5. Presence of switching frogs or grade crossings	+4
6. Tight radius curve	
a. Radius less than 600 feet	+4
b. Radius 600 to 900 feet	+0.5
c. Radius greater than 900 feet	0
7. Presence of bridgework	
a. Light steel trestle	+14
b. Heavy steel trestle	+5
c. Concrete structure	0

(Source: J.W. Swing, "Simplified Procedure for Developing Railroad Noise Exposure Contours," Sound and Vibration, February 1975, pg. 22.)

The equivalent number of operations is calculated as

$$N = N_D + 10\ N_N$$

$$+ 30 + 10(17) = 200$$

Entering Figure 2, the following Ldn levels are obtained:

At 100 ft, Ldn = 77 dBA

At 200 ft, Ldn = 72.5 dBA

At 1000 ft, Ldn = 59.5 dBA

Example

Develop Ldn contours for the train operations in previous example assuming the presence of a grade crossing.

The equivalent number of operations remains at 200 as already calculated. To obtain the Ldn contours,(8) the following table is constructed:

Desired Contour Value, dBA	Adjusted Factor from Table 3	Adjusted Contour Value, dBA	Distance to Desired Contour Value, ft.
80	4	76	125
75	4	71	260
70	4	66	460
65	4	61	850
60	4	56	1500

Due to the presence of the grade crossing, the desired contour distances, which would normally be obtained directly from Figure 8, are spread out further from the track centerline. Consequently, column 3 lists the adjusted contour values which are obtained by substracting the adjustment factor in column 2 from the desired contour value in column 1. Now enter Figure 8 with these adjusted contour values to obtain the distance to the desired contour values as listed in column 4. For example, the 80 dBA contour is 125 ft. from the track centerline, the 75 dBA contour is 260 ft. from the track centerline, etc.

FIXED WING AIRCRAFT NOISE PREDICTOR

With the advent of jet engine aircraft in the late 1950's, noise exposure levels increased appreciably from aircraft operation around air installations. This led to the development of cumulative noise exposure ratings, such as the community noise rating (CNR) for aircraft, the noise exposure forecast (NEF), and the community noise equivalent level (CNEL). Each of these methods essentially add the noise effects on an energy basis and include penalties for sensitive periods of a 24-hour cycle.[1]

Computer programs exist [9,10] which generate noise level contours due to flight operations from fixed wing aircraft around airports. Likewise, there exists [2,11] a hand calculation method, to be described in this manual, which provides approximate Ldn levels at fixed points around the airport. It is emphasized that this short method of predicting aircraft noise does not include many complicating factors which are built into the computer programs. However, while the short method provides only approximate Ldn levels, it does allow relative comparisons among different sets of flight operations around an airport. This information can be useful to a planner who needs a quick evaluation of possible noise strategies related to aircraft operational changes.

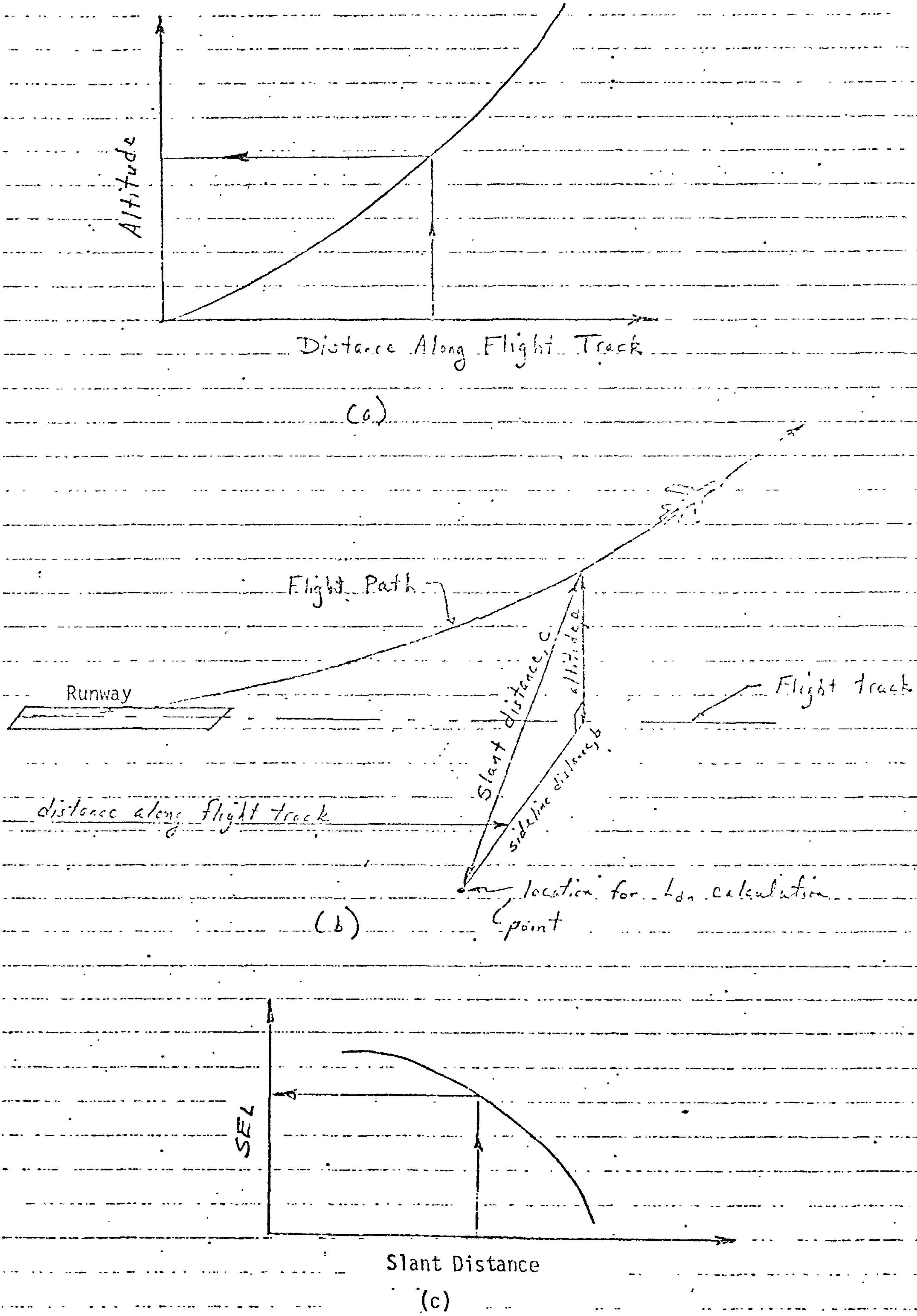


Figure 8 - Graphical Sequence for Calculating SEL

Required Information

The aircraft noise predictor requires the following information:

1. The flight track locations around the airport.

2. The relationship between the aircraft altitude and the distance along the flight track (the projection of the aircraft position onto the ground plane) for each aircraft operation.

3. The relationship between the SEL and the slant distance for the point location in question.

4. The average daily number of each aircraft operation, by daytime and nighttime operations.

5. Runway utilization and flight path utilization in terms of percentage for each operation.

Procedure

Figure 8 shows the geographical procedure for establishing the SEL for a given class of aircraft at a selected location.

1. Establish the distance along the flight track location and enter the appropriate altitude profile curve, such as Figure 8 (a). Read the corresponding altitude.

2. Having the altitude, a, and knowing the sideline distance, b, as shown in Figure 8 (b), calculate the slant distance, c, as follows:

$$c = a^2 + b^2$$

(The altitude shown in Figure 8 (b) is actually an approximation of the true altitude which is on a line perpendicular to the flight path. For purposes of this manual, the approximate altitude is adequate.)

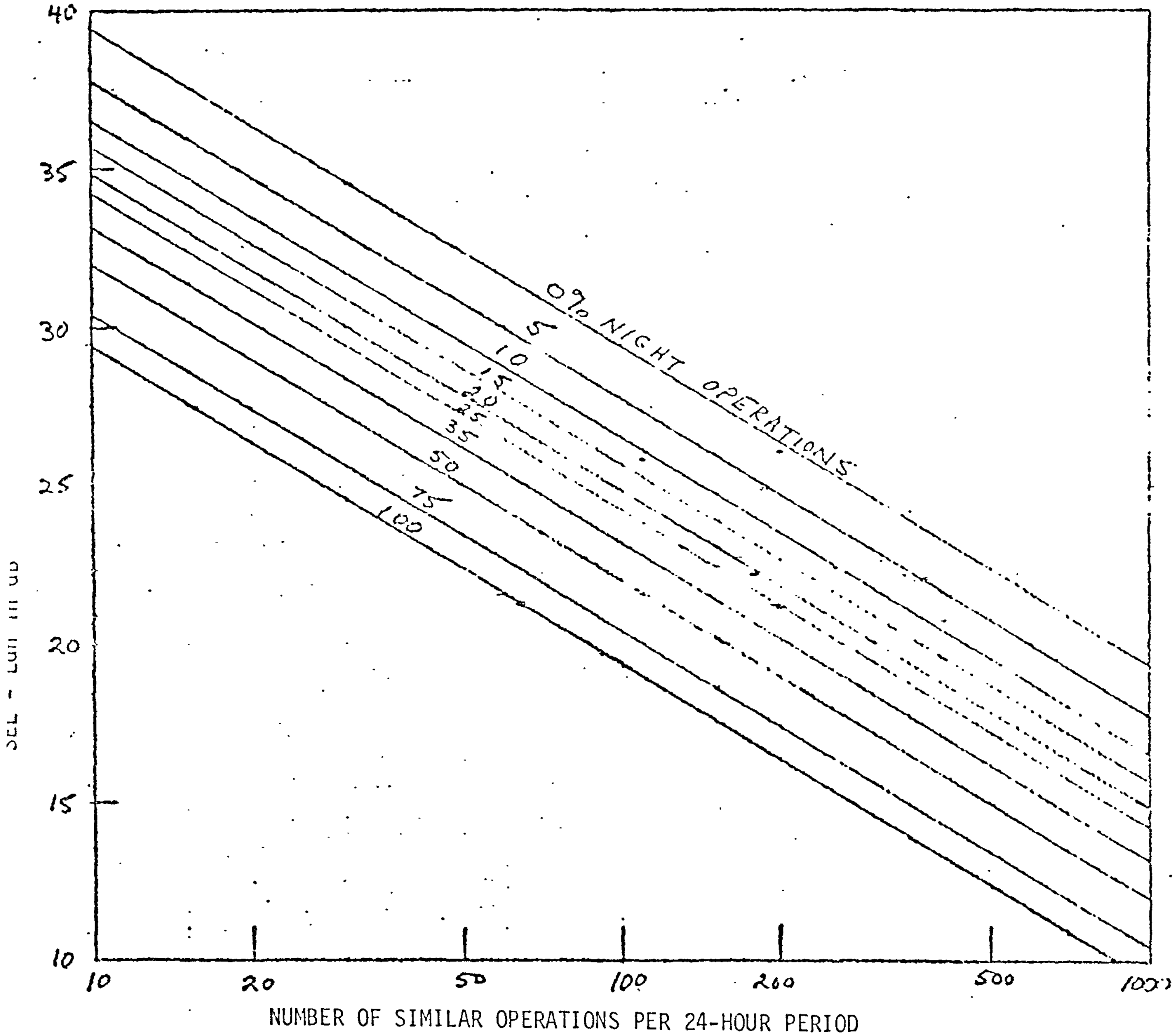


FIGURE 9

Ldn CHART FOR SINGLE EVENTS

(Source: "Task II - Joint Services Noise Planning Manual," by Wilsey & Ham prepared for the Washington Area Procurement Center, Nov. 1974.)

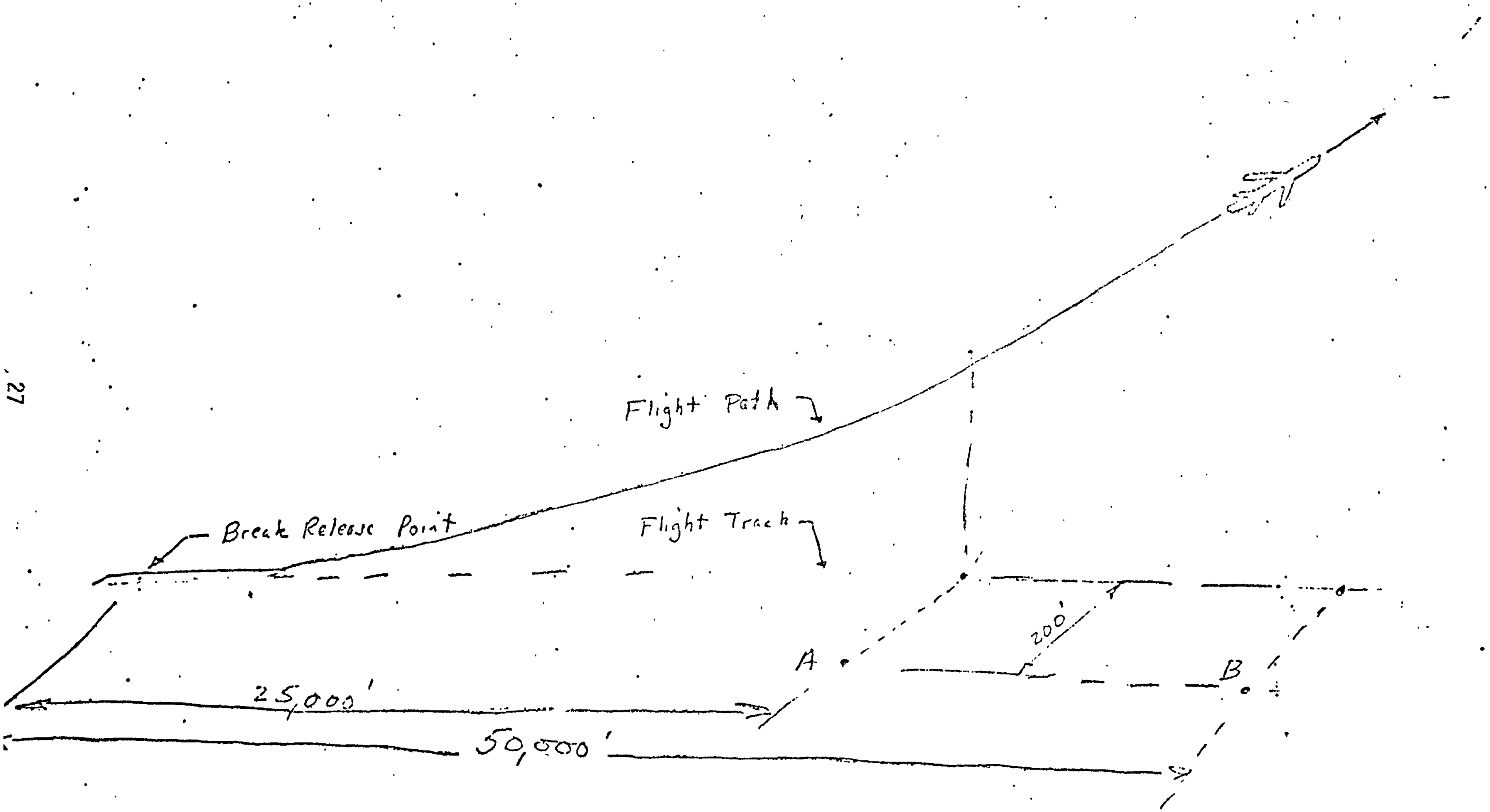


FIGURE 10 - Location of Points A and B from the Break Release Point

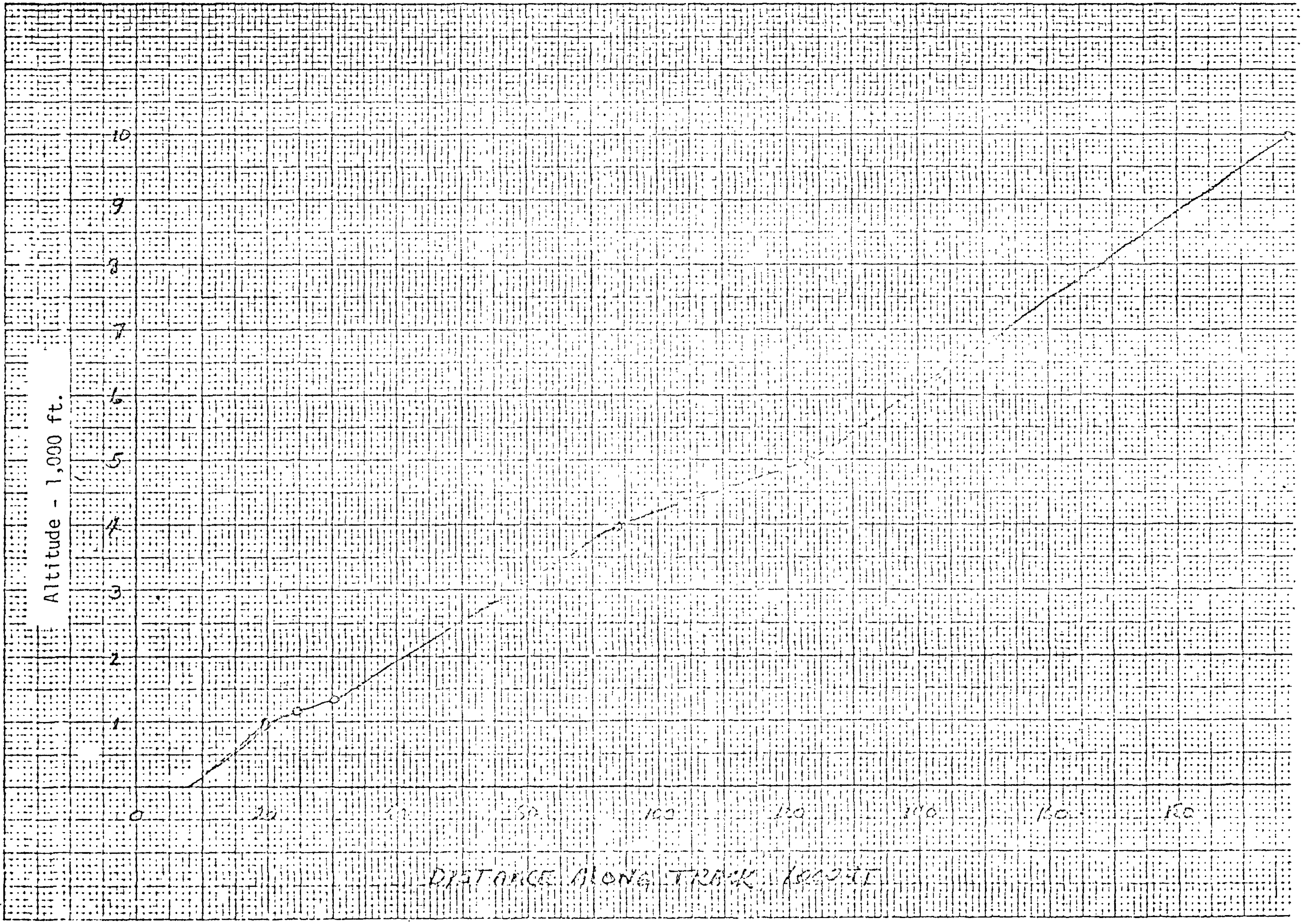


FIGURE 11 - Flight Profile for Alpha Takeoff Procedure for 707-300B @ 320,000 lb. Gross Weight

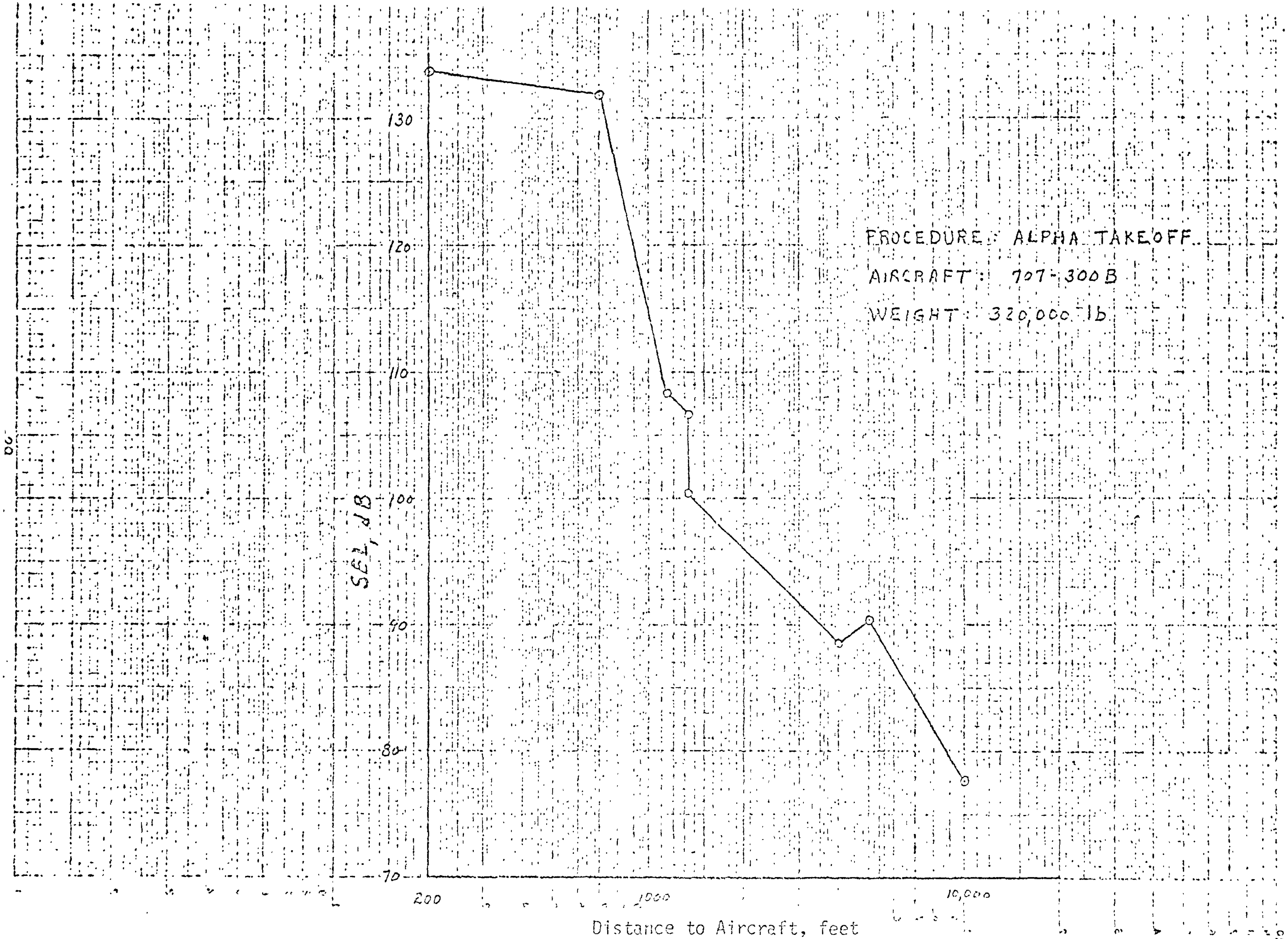


Figure 12 - SEL Variation with Distance

3. Enter the SEL - slant distance curve, such as Figure 8(c), with the slant distance to obtain the corresponding SEL value.

4. Knowing the number of similar flight operations and the number of daytime and nighttime flights, enter Figure 9 to obtain the difference between SEL and Ldn. Knowing SEL from step 3, the Ldn contribution for the set of flight operations at the location in question and for the particular flight track is established.

5. Repeat steps 1 through 4 for the other classes of aircraft using the same flight track.

6. Repeat steps 1 through 5 for the remaining flight tracks around the air installation.

7. Add all Ldn levels using Figure 1 to obtain the overall Ldn level.

Example

Calculate the Ldn at points A and B in Figure 10 due to an alpha takeoff procedure by a Boeing 707-300B at 320,000 lb. gross weight. Assume 50 daily flights of which 20% occur at night.

Figure 11 shows the altitude profile for this aircraft under this take-off procedure, while Figure 12 is the corresponding SEL variation with distance. To calculate the SEL for points A and B, the following steps are made:

Point A: Altitude a = 1170 ft. (from Figure 11)

Sideline Distance b = 200 ft.

Slant Distance c = $(1170)^2 + (200)^2$ = 1187 ft.

SEL = 108 dB (from Figure 12)

SEL - Ldn = 27.7 dB (from Figure 9)

Ldn = 108 - 27.7 = 80.3 dB Answer

Point B: Altitude a = 2200 ft (from Figure 11)

sideline distance b = 200 ft.

slant distance c = $\sqrt{(2200)^2 + (200)^2}$ = 2209 ft.

SEL = 95 dB (from Figure 12)

SEL - Ldn = 27.7 dB (from Figure 9)

Ldn = 95-27.7 = 67.3 dBA Answer

CONCLUDING REMARKS

Each noise predictor method contained in this manual has been presented in an abbreviated form to be used by non-technical individuals who need to estimate the noise impact from transportation sources.

It is emphasized that these methods provide only approximate Leq and Ldn levels for any given situation. Yet, this information is useful to the planner to identify potential noise problems and to assess relative comparisons among different sets of conditions. References on more complex noise predictor methods are included for those readers who have need for a more complete treatment of their noise problems.

REFERENCES

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10. "Community Noise Exposure Resulting from Aircraft Operations: Computer Program Description," Air Force Report AMRL TR-73-109.

11. "Community Noise Exposure Resulting from Aircraft Operations: Application Guide for Predictive Procedure," Air Force Report AMRL TR-110.

APPENDIX A

ROADWAY SEGMENTS

CORRECTION TABLE FOR ROADWAY LENGTH

$\frac{AC}{DC}$ or $\frac{BC}{DC}$	Correction (dB)
4.0	- 0.3
3.5	- 0.4
3.0	- 0.5
2.5	- 0.6
2.0	- 0.7
1.5	- 0.9
1.0	- 1.3
0.75	- 1.5
0.5	- 1.9
0.25	- 2.4
0	- 3.0

Instructions for use of table:

Distances AC, BC and DC are shown in Figure 3. Determine these distances with a site plan and a scale or estimate them in the field. Compute the ratio AC divided by DC. The table gives the correction in decibels for the length of roadway to the left of the observer. Compute the ratio of BC divided by DC and obtain a correction for the length of roadway to the right of the observer. Add the two corrections and apply this to the levels obtained by the short method of highway noise prediction.

Example

The perpendicular distance from a roadway to an observation point is 200 ft. (DC = 200 ft.) The roadway extends 400 ft. to

APPENDIX A

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4.0	- 0.3
3.5	- 0.4
3.0	- 0.5
2.5	- 0.6
2.0	- 0.7
1.5	- 0.9
1.0	- 1.3
0.75	- 1.5
0.5	- 1.9
0.25	- 2.4
0	- 3.0

Instructions for use of table:

Distances AC, BC and DC are shown in Figure 3. Determine these distances with a site plan and a scale or estimate them in the field. Compute the ratio AC divided by DC. The table gives the correction in decibels for the length of roadway to the left of the observer. Compute the ratio of BC divided by DC and obtain a correction for the length of roadway to the right of the observer. Add the two corrections and apply this to the levels obtained by the short method of highway noise prediction.

Example

The perpendicular distance from a roadway to an observation point is 200 ft. (DC = 200 ft.) The roadway extends 400 ft. to the left and 600 ft. to the right of point C (AC = 400 and BC = 600 ft). Thus AC/DC = 2 and BC/DC = 3. The corrections for the length to the left is -0.7 dB, and -0.5 dB for the length to the right. The total correction for roadway length is -0.7 -0.5 = -1.2 dB. Thus, subtract 1.2 dB from the noise level computed for the highway.

APPENDIX B

BARRIER ATTENUATION

The following is a description of a short method of computing barrier attenuation that will give approximate results. The method is generally applicable to roadways, railroad, and most other noise sources. For more accurate calculations and for situations not covered here, the reader is referred to previously mentioned references. (3,4,5)

It will be necessary to have a scaled sectional drawing of the barrier, observer, and source as shown in Figure B1. Elevations and distances needed to construct this drawing can be obtained from the site plan drawing for the highway or railroad in question.

In Figure B1, distance OR is the observer's ear height above the ground. While this is often about five feet, the observer may be at a second story window. Distance SN is the height of the noise source above the roadbed or pavement. For automobiles, assume the noise source to be at the pavement level, or SN = 0. For trucks and railroad line operations, the distance SN can be taken as eight feet or the approximate height of the exhaust stack.

1 - Connect the observer and the source with a line called the line of sight as shown in Figure B1. Scale the distance H, which is the perpendicular distance from the line of sight to the top of the barrier (not necessarily the barrier height).

2 - From the section drawing (Figure B1), scale distances D_B, the horizontal distance from the observer to the barrier and D_R, the horizontal distance from the roadway centerline to the barrier.

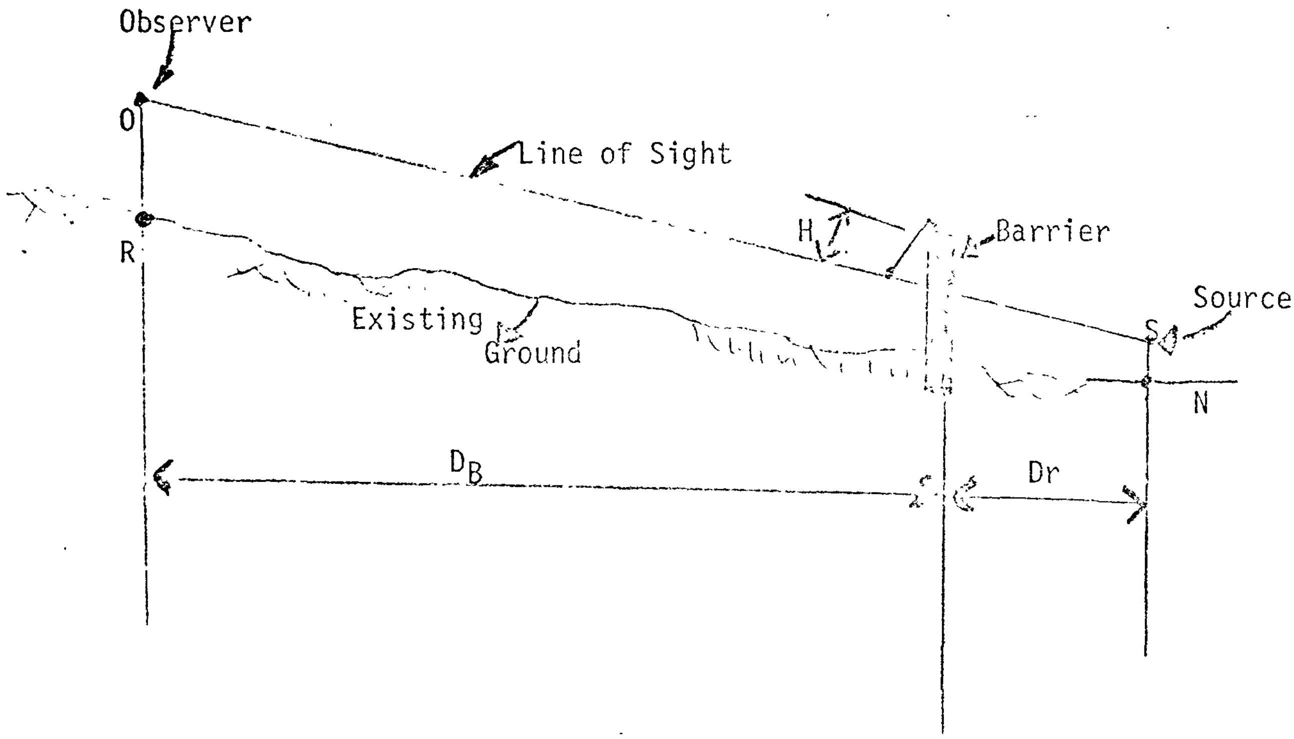

FIGURE B1 - Section View showing Barrier Parameters

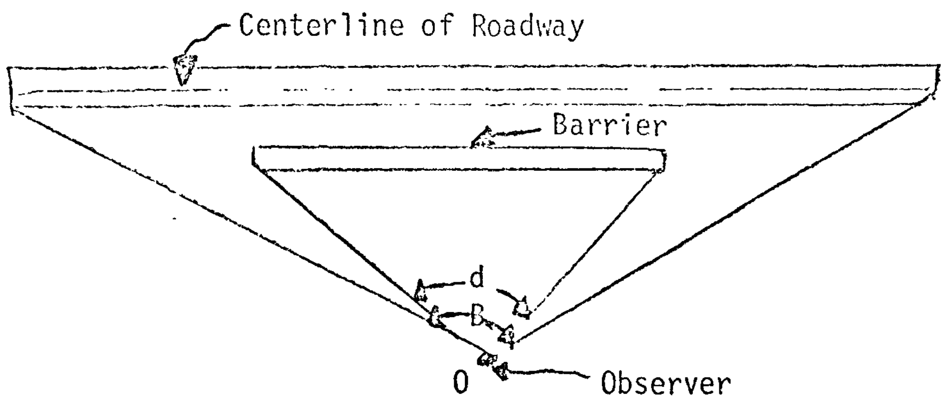

FIGURE B2 - Plan View of a Roadway Partially Shielded by a Barrier

3 - Compute the factors H^2/D_R and H^2/D_B.

4 - With the computed value of H^2/D_R, enter the horizontal axis of Figure B3. Now move upward (vertically) to the proper H^2/D_B curve. Note that it may be necessary to interpolate between the curves given in Figure B3. Now slide horizontally to the vertical axis and read the adjustment in decibels for the barrier.

In the case of highway noise it will be necessary to determine separately an adjustment for the automobile and truck traffic. This is because trucks and automobiles have different heights SN above the pavement. So the adjustments are different and they have to be separately applied to the truck noise and automobile noise before the latter are added to give the total roadway noise.

In the previously described method, it was assumed that the observer was shielded from the entire roadway. Figure B2 is a plan view of a barrier that is not long enough to shield the observer from the entire length of roadway. In this case it will be necessary to obtain the angles α and β from the site plan using a protractor. Often it will be sufficient to estimate the angles in the field, Then Step 5 is completed as follows:

5 - Compute the ratio, α divided by β . Enter Table B1 with this ratio and the adjustment in decibels from Step 4. This table gives the final barrier attenuation in decibels. Note that if the ratio of α/β is 1.0, or the barrier runs the full length of the roadway, then the adjustment determined in Step 4 does not change.

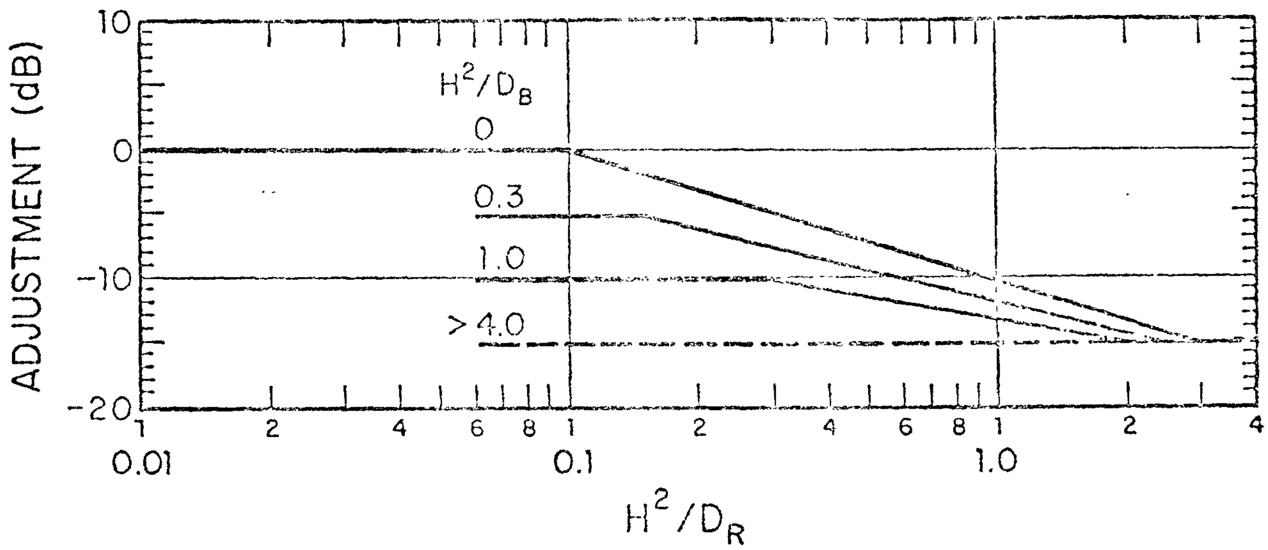

Figure B3 - Barrier Adjustment in dB from the Barrier Parameters, D_R, D_B, and H.

Adjustment from Step 4	Ratio d/B										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
-5dB	0	0	-1	-1	-1	-2	-2	-2	-4	-4	-5
-10dB	0	0	-1	-1	-2	-3	-3	-4	-6	-7	-10
-15dB	0	0	-1	-2	-2	-3	-4	-5	-7	10	-15

Table B1 - Barrier Attenuation corrected for Length of Barrier