

SPM9613 Users Manual

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2.0 Installation

Installation of SPM9613 is a simple but multi-step process.

1. The SPM9613 software must first be installed on your computer. This is accomplished by inserting the CDROM into your CD drive and executing the installation software setup.exe. You can either execute setup.exe through the Windows "Run" mode or by double clicking on the setup.exe file through your Windows file managing software. It is suggested that the user allow setup.exe to install SPM9613 in the default directory. Installing to the default directory is necessary to allow the samples files to work correctly.

Instructions below are applicable to the Commercial Version only. These are NOT applicable or necessary for successful installation of the Internet DEMO Version.)

1. The drivers for the hardware key must now be installed. Enter the HASPDrv directory (file folder) on the CDROM. Find the setup.exe file and execute it by double clicking on it.
2. After successful installation of the drivers. Power down your computer and all equipment attached to it.
3. Disconnect the printer or other parallel port devices from your computer and attached the HASP hardware key to your parallel port. Note: The HASP key unlocks the software so that all of SPM9613's available features can be used.
4. Reconnect your hardware (printer or other parallel port devices) to the open end of the HASP key.
5. Restart your computer.

SPM9613 is now ready to run.

The SPM9613 demo or commercial versions can be started through the icon in your program manager or by going to SPM9613.exe and double clicking on it. SPM9613.exe can be found on your hard drive in C:\SPM9613\SPM9613.exe if you let the setup program install SPM9613 in the default directory.

3.0 Technical Parameters

3.1 Basis

SPM9613 is based on ISO standards 9613 Parts 1 (1993) and 2 (1996). Extensions have been added to make the program user friendly. Because the standard does not address the details of some issues, interpretation and judgment have been used. All interpretations used are explained in the user's manual. User's are encouraged to purchase and read the above standards to fully understand the various limitations of the standards.

ISO 9613-1:1993(E) specifically addresses atmospheric attenuation while ISO 9613-2:1996(E) specifies an engineering method for calculating environmental noise from a variety of noise sources by prescribing methods to determine the various attenuation effects observed during outdoor sound propagation. ISO 9613-2 assumes the user wishes to evaluate outdoor noise propagation during meteorological conditions favorable to sound propagation (downwind propagation with velocities between 1 and 5 m/s when measured 3 to 11 m above the ground). The standard does not provide a means for evaluating sound emission under non-favorable conditions but does provide guidance for estimating long term average sounds levels over a long period of time (a year for example) due to a variety of environmental conditions.

Specifically, ISO 9613-2 provides methods to allow users to address:

Geometrical Divergence of point sources
 Atmospheric Absorption - ISO 9613-1
 Ground Attenuation (or reinforcement) from soft or hard ground
 Attenuation from Screens/Barriers
 Miscellaneous Attenuation from industrial sites and foliage
 Reflections
 Directivity of sources

3.2 SPM9613 Features and Extensions

SPM9613 features and extensions include:

- Automatic breakdown of large 3 dimensional or line sources into multiple point sources
- User ability to limit ground attenuation effects
- Octave band center Frequency range from 16 Hz to 8000 Hz
- Computation of C-weighted sound levels
- Automatic sorting, highest to lowest of spectra on A or C-weighting
- Contour plotting of A or C weighted sound levels
- Plan views of equipment, barriers, foliage or industrial sites, and observers
- Source Sound Power Level Spectrum plots and directivity plots (both vertical and horizontal)
- 3-D Ground Elevation plots
- Ground Hardness contours
- Sound Source waterfall plots at each observer location
- Multiple screens/barriers
- First reflections based on image sources

3.3 System Requirements

The minimum system requirements are:

80486DX or Pentium computer running Windows 3.1, 95, 98 or NT, Microsoft compatible mouse.

8 Megs of RAM (the more RAM, the faster the calculations will be)

20 Megs of hard disk space

CDROM Drive (standard media distribution) , 1.44 Meg Floppy disks are available at an extra charge.

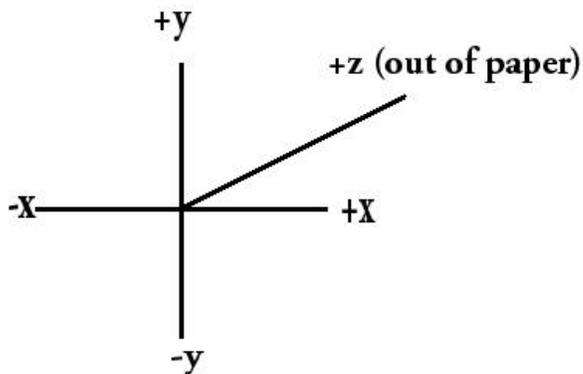
Video resolution: 800x600 (with small font video mode) or 1024x768 (with large font video mode).

While SPM9613 can support other graphics modes, they will likely be unacceptable to most users.

3.4 Coordinate System

The coordinate system is define as follows:

Values of x and y correspond to locations in the horizontal plane. The positive y axis rotates clockwise into positive x axis. Positive z is above the horizontal plane.



For maximum flexibility, the source directivity angles are handled independently of the coordinate system shown and are tied to the source coordinates.

See source directivity for further information.

3.5 Basic Equations

The basic equation used in ISO 9613-2 to define the downwind sound at a receiver is:

$$L_p(\text{downwind}) = L_{w_{\text{point}}} + D - A$$

where

$L_{w_{\text{point}}}$ is the point source sound power level, in dB re 1 picowatt

D is the directivity indices, in dB

A is the attenuation of various effects defined by:

$$A = A_{\text{div}} + A_{\text{atm}} + A_{\text{ground}} + A_{\text{screen}} + A_{\text{misc}}$$

A_{div} is the attenuation due to geometrical divergence

A_{atm} is the attenuation due to atmospheric absorption

A_{ground} is the attenuation due to the ground effect

A_{screen} is the attenuation due to screening

A_{misc} is the attenuation due to miscellaneous effects (propagation through industrial sites or foliage)

The following defines the details of how each of the above terms are handled in SPM9613.

3.6 Sound Source Definition

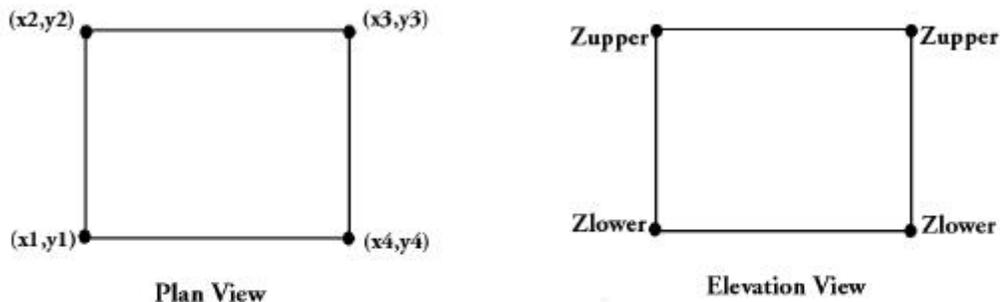
ISO 9613-2 requires that all sound sources must be defined as point sources. For large sound sources that are closer to the receiver than “twice the diameter of the relevant area of sources”, or when the source is partially blocked by a barrier, the standard says the source must be broken down into several points. SPM9613 can, at the users discretion, allow the large three dimensional source or line source to be automatically broken down into 6 or 54 individual point sources. The user can then quickly define the source without the tedious task and associated interpretation difficulty of results from many points representing a small portion of the same physical source. Barriers, reflectors and all propagation path information is treated independently for each of the sub sources.

NOTE: It should be noted that while the 6 or 54 point distributed sources improve the source representations relative to a single point source, 6 or 54 points may still not be adequate to define receiver positions close to the source. The user must verify that meeting the minimum distance requirement of the ISO9613 standard is achieved. If the minimum distance requirement is not, the user should further break down sources into smaller sub sources until the minimum distance requirement is satisfied.

The sound sources are defined as follows:

The user selects whether he wants a point source, line source and three dimensional (box) source.

If the user selects a point source or a 3-D source, he will be allowed to enter values corresponding to the four corners $\{(x1,y1), (x2,y2), (x3,y3), (x4, y4)\}$ of the physical source and the upper and lower surface elevations $\{(Zupper, Zlower)\}$ *Note: The corner points must be entered in a clockwise rotation, starting at $(x1,y1)$ to assure the directivity is treated correctly.*



If the **point source** is selected, a single point will represent the total source and be located at the average value of points $(x1,y1), (x2,y2), (x3,y3), (x4, y4)$ and the average of the upper and lower elevations. All of the sound power level will be concentrated at this point.

If the **3-D source** is selected, the user has the option of determining which sides, or if all of the 6 sides should be included in the source representation.

The distribution of points for surface sources is determined as follows:

The areas of each of the vertical “walls” is calculated by:

$$S_{(1>2)} = i_{(1>2)}(Z_{\text{upper}} - Z_{\text{lower}}) * [(x_2 - x_1)^2 + (y_2 - y_1)^2]^{1/2}$$

$$S_{(2>3)} = i_{(2>3)}(Z_{\text{upper}} - Z_{\text{lower}}) * [(x_3 - x_2)^2 + (y_3 - y_2)^2]^{1/2}$$

$$S_{(3>4)} = i_{(3>4)}(Z_{\text{upper}} - Z_{\text{lower}}) * [(x_4 - x_3)^2 + (y_4 - y_3)^2]^{1/2}$$

$$S_{(4>1)} = i_{(4>1)}(Z_{\text{upper}} - Z_{\text{lower}}) * [(x_1 - x_4)^2 + (y_1 - y_4)^2]^{1/2}$$

For the upper and lower surfaces, the average length of opposite sides is calculated by:

$$L_1 = 1/2\{[(x_2 - x_1)^2 + (y_2 - y_1)^2]^{1/2} + [(x_4 - x_3)^2 + (y_4 - y_3)^2]^{1/2}\}$$

$$L_2 = 1/2\{[(x_3 - x_2)^2 + (y_3 - y_2)^2]^{1/2} + [(x_1 - x_4)^2 + (y_1 - y_4)^2]^{1/2}\}$$

The areas of each of the upper and lower surfaces is calculated by:

$$S_{(\text{lower})} = i_{(\text{lower})} L_1 L_2$$

$$S_{(\text{upper})} = i_{(\text{upper})} L_1 L_2$$

where the values of “i” are either 0 or 1 indicating whether or not the side is included in the calculation. 0 indicates the side is not included, while 1 indicates the side is included.

It should be clear from the above procedure that not all 3-D source representations will be valid. For example, the source plan view cannot have any crossing lines (lines making an “X” shape in the plan view). Shapes should have “nearly” 90 degree corners (in the plan view) to assure the upper and lower surface areas are estimated with reasonable accuracy.

The total 3-D Area $S_{(\text{total})}$ is calculated by:

$$S_{(\text{total})} = S_{(1>2)} + S_{(2>3)} + S_{(3>4)} + S_{(4>1)} + S_{(\text{lower})} + S_{(\text{upper})}$$

The power level of the side defined by points x_1, y_1 and x_2, y_2 is calculated by:

$$LW_{(1>2)} = LW_{(\text{total source})} + 10\text{Log}_{10}(S_{(1>2)} / S_{(\text{total})})$$

This equation is repeated substituting the area term for the other 5 sides.

For a 6 point distributed source, a single point is placed at the average elevation of each surface and average xy position of the line in the plan view. If the user elects not to include some of the sides, the total number of points representing the source will be less than 6.

As an example, the sound power defined at the center point on the side defined by points x_1, y_1 and x_2, y_2 is;

$$LW_{\text{point}} = LW_{(1>2)}$$

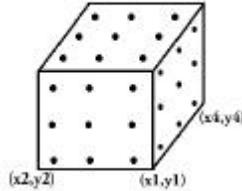
Where LW_{point} is term sound power level term in the **basic equation**.

Each of the 6 sides is handled in a similar fashion.

For a 54 point approximation, a grid of 9 evenly spaced points (3 rows of 3 columns) are placed on each side. The grid of points are spaced at 1/6, 1/2 and 5/6 the length or height from the edge of the side. If the user elects not to include some of the sides, the total number of points representing the source will be less than 54.

As an example, the sound power defined at each of the nine (9) points on the side defined by points x_1, y_1 and x_2, y_2 is;

$$L_{W_{\text{point}}} = L_{W_{(1>2)}} + 10\text{Log}_{10}(1/9)$$



If the user selects a line source, he will be allowed to enter values corresponding to the line defined by $\{(x_1, y_1), (x_2, y_2)\}$, and elevation Z_{lower} .

Either 6 or 54 points (depending on the run time selection) will be evenly spaced along the line. Two of the points will include the (x_1, y_1) and (x_2, y_2) positions. The sound power level of each point on the line will be:

$$L_{W_{\text{point}}} = L_{W_{(\text{total source})}} + 10\text{Log}_{10}(1/6)$$



or

$$L_{W_{\text{point}}} = L_{W_{(\text{total source})}} + 10\text{Log}_{10}(1/54)$$

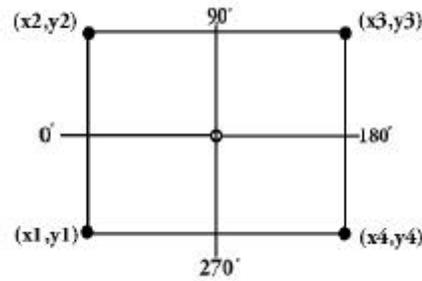
3.7 Source Directivity

The directivity indices, D , is a frequency and direction dependent term. It is handled by allowing the user to input indices, in decibels, at 10 degree increments to be added to the sound power level.

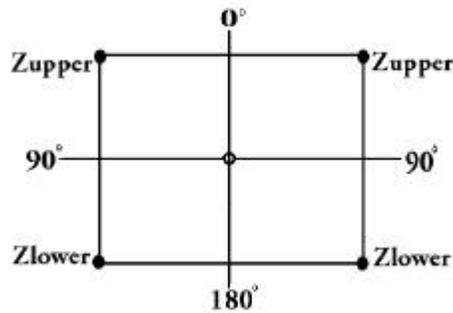
The source directivity is tied to the coordinates defining the 3-dimensional shape of the source. Because the directivity is tied to the source coordinates, the directivity information can only be input for point and 3-dimensional sources. **If the user selects a point source or a 3-D source**, he will be allowed to enter values corresponding to the four corners $\{(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)\}$ of the physical source and the upper and lower surface elevations $\{Z_{\text{upper}}, Z_{\text{lower}}\}$ *Note: The corner points must be entered in a clockwise rotation, starting at (x_1, y_1) to assure the directivity is treated correctly. See figure on directivity in the horizontal plane below.*

The points defining the **line sources** are assumed to be omnidirectional. If the line source cannot be properly represented by a series of omnidirectional points, the user must define individual point sources to represent the line.

In the horizontal direction, 0° is referenced as the direction defined by an origin point in the center of the source that passes through the mid point of the side defined by $\{(x_1, y_1), (x_2, y_2)\}$. The angles progress from 0° to 360° as the receiver moves clockwise around the source.



In the vertical direction, 0° is referenced as the direction defined by an origin point in the center of the source that passes through the mid point of the top side of the source. The angles progress from 0° to 180° as the receiver moves toward the ground. At 90°, the receiver is at the same elevation as the center point of the source.



3.8 Divergence

The Divergence term A_{div} is calculated as follows:

$$A_{div} = 20\text{Log}_{10}(d) + 11, \text{ dB}$$

where d is the source to observer distance, in meters.

3.9 Atmospheric Absorption

The atmospheric absorption term, A_{atm} , is highly dependent on distance, relative humidity and temperature and weakly dependent on pressure. A_{atm} is calculated using the procedures defined in ISO 9613-1 and will not be discussed in detail here.

The following table illustrates of the level of attenuation, observed at a distance of **1000 meters**, 20° C and 70% humidity.

| Octave Band Center Frequency, Hertz | | | | | | | | | |
|-------------------------------------|-------------|-----------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <u>16</u> | <u>31.5</u> | <u>63</u> | <u>125</u> | <u>250</u> | <u>500</u> | <u>1000</u> | <u>2000</u> | <u>4000</u> | <u>8000</u> |
| 0 | 0 | 0.1 | 0.3 | 1.1 | 2.8 | 5.0 | 9.0 | 22.9 | 76.6 |

The above coefficients (or coefficients as calculated by ISO 9613-1) are multiplied by the actual distance then divided by 1000 meters to obtain atmospheric attenuation at other distances.

While ISO 9613-1 suggests limiting the individual octave band's atmospheric attenuation to 15 dB, the current ISO 9613-2 document does not suggest this limitation. The 15 dB limit is **NOT** used in SPM9613.

The following table illustrates of the level of atmospheric attenuation, observed at a distance of **500 meters**, 20° C and 70% humidity.

| Octave Band Center Frequency, Hertz | | | | | | | | | |
|-------------------------------------|-------------|-----------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <u>16</u> | <u>31.5</u> | <u>63</u> | <u>125</u> | <u>250</u> | <u>500</u> | <u>1000</u> | <u>2000</u> | <u>4000</u> | <u>8000</u> |
| 0 | 0 | 0 | 0.1 | 0.5 | 1.4 | 2.5 | 4.5 | 11.5 | 38.3 |

3.10 Ground Effects

The ground effect assumes there is a source, middle and receiver component which are frequency dependent. The main parameters are the heights above the ground plane for the source, h_s , and the receiver height, h_r , a number defining the ground hardness (quasi-absorption coefficient) {Gs, Gm or Gr} and the ground plane distance d_p .

The ISO 9613 standard assumes that the ground has a more-or-less constant slope between the source and the observer. When the slope between the source and observer is other than zero, the coordinate system must be transformed to define the projected distance and "apparent height" above the ground plane.

The determination of the transformed projected ground plane distance, d_p , and the source and observer heights above the ground plane are defined as follows:

Three terms along the ground plane are defined:

$$\begin{aligned} x'g &= [(x_s - x_o)^2 + (y_s - y_o)^2 + (z_g - z_{go})^2]^{1/2} \\ x's &= h's \cdot \sin(\theta) \\ x'o &= h'o \cdot \sin(\theta) \end{aligned}$$

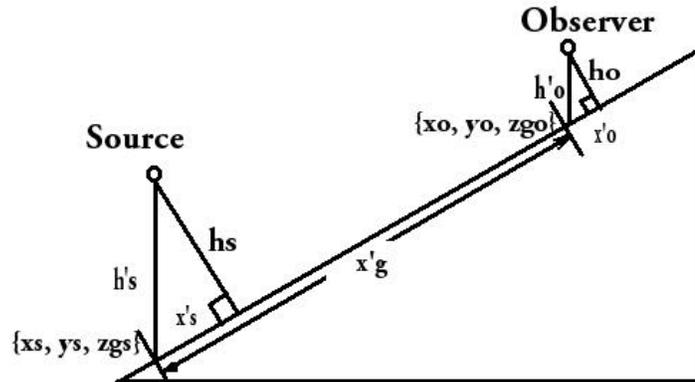
where

x_s, y_s the source x and y coordinates
 z_g is the ground elevation at the source
 x_o, y_o the observer x and y coordinates
 z_{go} is the ground elevation at the observer
 $h's$ is the vertical source height above the ground
 $h'o$ is the vertical observer height above the ground

$$\sin(\theta) = (z_{go} - z_g) / x'g$$

The transformed ground plane distance, dp , and transformed heights above the ground plane h_s & h_r are defined below:

$$\begin{aligned} dp &= x'g - x's + x'o \\ h_s &= h's \cdot \cos(\theta) \\ h_o &= h'o \cdot \cos(\theta) \end{aligned}$$



The formulas for the ground effect are:

| Octave Band Center Frequency, Hertz | Source or Receiver Attenuation A_s or A_r | Mid Ground Attenuation A_m |
|---|---|------------------------------------|
| 16 | -1.5 | -3q |
| 31.5 | -1.5 | -3q |
| 63 | -1.5 | -3q |
| 125 | $-1.5 + \{G_s \text{ or } G_r\} \cdot a'(h)$ | $-3q \cdot (1 - G_m)$ |
| 250 | $-1.5 + \{G_s \text{ or } G_r\} \cdot b'(h)$ | $-3q \cdot (1 - G_m)$ |
| 500 | $-1.5 + \{G_s \text{ or } G_r\} \cdot c'(h)$ | $-3q \cdot (1 - G_m)$ |
| 1000 | $-1.5 + \{G_s \text{ or } G_r\} \cdot d'(h)$ | $-3q \cdot (1 - G_m)$ |
| 2000 | $-1.5(1 - \{G_s \text{ or } G_r\})$ | $-3q \cdot (1 - G_m)$ |
| 4000 | $-1.5(1 - \{G_s \text{ or } G_r\})$ | $-3q \cdot (1 - G_m)$ |
| 8000 | $-1.5(1 - \{G_s \text{ or } G_r\})$ | $-3q \cdot (1 - G_m)$ |

where

$$\begin{aligned} a'(h) &= 1.5 + 3.0 \exp(-0.12 \cdot (h-5)^2) p' + 5.7 \exp(-0.09h^2) [1 - \exp(-2.8 \cdot 10^{-6} \cdot dp^2)] \\ b'(h) &= 1.5 + 8.6 \exp(-0.09 \cdot h^2) p' \\ c'(h) &= 1.5 + 14.0 \exp(-0.46 \cdot h^2) p' \\ d'(h) &= 1.5 + 5.0 \exp(-0.9 \cdot h^2) p' \\ p' &= 1 - \exp(-dp / 50) \\ dp &= \text{ground plane distance from source to receiver} \\ q &= 0, \text{ for } dp \leq 30(h_r + h_s) \text{ or} \\ q &= 1 - 30(h_r + h_s) / dp, \text{ when } dp > 30(h_r + h_s) \end{aligned}$$

Generically, the value G is defined as the ground hardness indicator, or absorption coefficient, 0 for hard ground, 1 for very soft ground. Values should be input between 0 and 1 for mixed ground.

Specifically,

G_s is the ground hardness at the source
 G_m is the ground hardness at the middle ground
 G_r is the ground hardness at the receiver

$$A_{\text{ground}} = A_s + A_m + A_r$$

When contour points are selected, G_m is determined by finding the mid point between the source and receiver. The ground value corresponding to the grid point closest to this mid point is the value used in the calculation.

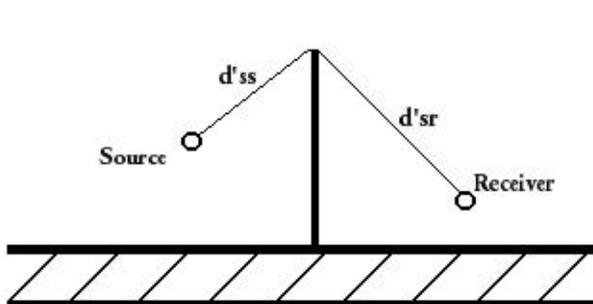
When user defined observers (individually defined observers) are selected, the mid ground hardness is input.

ISO 9613-2 provides no guidance on limiting the attenuation of the ground effect. However, “*Noise and Vibration Control Engineering*”, by Beranek and Ver, shows the “Practical Limit” to be about 20 dB relative to hard ground, and a “Conservative Limit” of 10 dB relative to hard ground. SPM9613 allows the user to select either the practical or conservative limit.

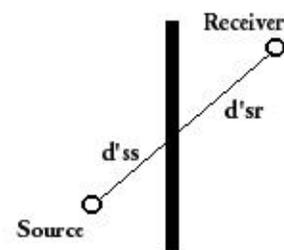
3.11 Screening (Barriers)

Screening is calculated for single or multiple screens. The screens are first checked to see if they intersect the line connecting the source to receiver paths in the horizontal plane. If the screen is found to intersect this line, the elevation of the direct path at the screen intersection is calculated based on straight line (line of sight) propagation. If the screen blocks the line of sight, the observer is in the “shadow zone”, if the observer can be seen when viewed from the source, the observer is in the bright zone.

Meteorological effects, from downwind propagation, are handled within the screening attenuation equation. The screen’s attenuation is NOT further reduced by assuming a 5000 meter radius “curved path” propagation which would presumably double account for the Meteorological effects.



Elevation View of Screen (Barrier)



Plan View of Screen (Barrier)

The horizontal dimension of the screen, perpendicular to the line connecting the source to receiver, must be greater than one wavelength of the center frequency of interest to be considered a screen as well as the

barrier's height must be greater than $\frac{1}{2}$ wavelength. The $\frac{1}{2}$ wavelength height limit is necessary to eliminate attenuation of sources in the "bright zone" from short screens.

ISO 9613-2 warns that for large distances and high barriers, the insertion loss calculated has not been sufficiently confirmed by measurements.

Single screens include multiple paths for sound propagation. The following propagation paths are considered; around each of the vertical sides (unless overridden in the barrier definition) and over the top of the barrier. The path attenuation is summed and the final attenuation determined. The maximum attenuation allowed by a single screen is 20 dB.

Whether or not propagation around a side can occur is a user input. This is useful when defining multiple connecting barriers.

Multiple screens assume the attenuation around the barrier is adequate and estimate only the path over the top of the barrier. All combinations of screens existing between the source and observer are computed first singularly, then in pairs. When computed in pairs, the barrier combination providing the largest attenuation is used in the screening attenuation term. To be considered a double screen, the line of sight must be broken by the second screen of the pair when the observer is viewed from the top of the screen closest to the source. If the distance between the first screen and second screen is less than one wave length of the center frequency of interest, the maximum attenuation of that octave band is set to 20 dB. If the distance between the first screen and second screen is greater than or equal to one wave length, the maximum attenuation allowed by the double screen is 25 dB.

If one screen is significantly taller than all other screens, all other barriers may be in bright zone when viewed from the top of the tallest barrier. In this case, the attenuation of the single screen may be used as the largest attenuation. However, because the single screen is limited to a maximum of 20 dB, SPM9613 will then look for any other pair of screens between the source and receiver that would provide higher attenuation, up to the maximum double screen limit of 25 dB.

The screening attenuation (D_z) is calculated with the following equations:

$$D_z = 10 \log_{10} (3 + (20 / \lambda) C_3 z K_{met}), \text{ in dB}$$

where

λ is the wavelength of the sound
 z is the difference between the direct and refracted path lengths
 $C_3 = (1 + (5\lambda/e')^2) / (1/3 + (5\lambda/e')^2)$ for multiple screens, or = 1 for single screens
 e' is the distance between the screens in the direction of the source and receiver, accounting for the distance component parallel with the screen.

K_{met} is the correction factor for meteorological influences, defined as

$$K_{met} = \exp (-(1/2000) ((d_{ss} \cdot d_{sr} \cdot d) / 2z)^{1/2}) \text{ for } z > 0$$

or

$$K_{met} = 1 \text{ for other values of } z \text{ or lateral diffraction}$$

d_{ss} perpendicular distance from source to plane of screen.

d_{sr} perpendicular distance from plane of screen to receiver.

d'_{ss} distance from source to screen in the direction of the source and receiver, accounting for the distance component parallel with the screen.

d'_{sr} distance screen to receiver in the direction of the source and receiver, accounting for the distance component parallel with the screen.

d distance source to receiver

$$z = d'ss + d'sr + e' - d$$

The value of z is given a negative value if the observer is in the bright zone of the screen.

In simplistic terms, the Screen Attenuation is defined as the larger of either the Screen Attenuation alone or the Ground Attenuation. Mathematically, the screening term, A_{screen} , is defined as follows:

For top edge attenuation due to the screen:

$$A_{\text{screen}} = Dz - A_{\text{ground}}$$

If $A_{\text{screen}} < 0$, A_{screen} is set equal to 0.

For side edge attenuation due to the screen:

$$A_{\text{screen}} = Dz$$

The A_{ground} term will then cancel when it is added in the basic attenuation equation.

3.12 Miscellaneous Attenuation

For the purposes of this document, miscellaneous attenuation is defined as the attenuation from industrial sites and foliage. The foliage and industrial site areas are defined with four points, corners $\{(x1,y1), (x2,y2), (x3,y3), (x4, y4)\}$, similar to those used to define the sound sources. The four lines made by connecting points $\{(x1,y1), (x2,y2)\}$, $\{(x2,y2), (x3,y3)\}$, $\{(x3,y3), (x4, y4)\}$, and $\{(x4,y4), (x1,y1)\}$ are first checked to see if any of them intersect the line connecting the source to receiver paths in the horizontal plane. If the industrial site or foliage area is found to intersect the source to receiver line, the elevation of the direct path at the area is calculated by taking small steps through the industrial site or foliage area in the horizontal plane, determining the x , and y coordinates, then calculating the elevation of the sound ray at that point based on a curved path propagation with a radius equal to 5000 meters. If the height of the foliage or industrial site is less than that of the curved path elevation no attenuation is provided. If the height of the foliage or industrial site is greater than that of the curved path elevation, the distance in the x - y plane through the area is calculated and summed with that from the previous steps through the area.

The resulting total distance through all of the industrial site areas is defined as di , while the total distance through all the foliage is defined as df .

The attenuation of the foliage, A_f , is defined by multiplying the distance, df , by the following coefficients:

| Octave Band Center Frequency, Hertz | | | | | | | | | |
|-------------------------------------|------------------|-------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| $\frac{16}{0}$ | $\frac{31.5}{0}$ | $\frac{63}{0.02}$ | $\frac{125}{0.03}$ | $\frac{250}{0.04}$ | $\frac{500}{0.05}$ | $\frac{1000}{0.06}$ | $\frac{2000}{0.08}$ | $\frac{4000}{0.09}$ | $\frac{8000}{0.12}$ |

If df is > 200 meters, it is limited to 200 meters for the purpose of calculating A_f .

The attenuation of the industrial sites, A_i , is defined by multiplying the distance, di , by the following coefficients:

| Octave Band Center Frequency, Hertz | | | | | | | | | |
|-------------------------------------|------------------|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------------|----------------------|
| $\frac{16}{0}$ | $\frac{31.5}{0}$ | $\frac{63}{0}$ | $\frac{125}{0.015}$ | $\frac{250}{0.025}$ | $\frac{500}{0.025}$ | $\frac{1000}{0.02}$ | $\frac{2000}{0.02}$ | $\frac{4000}{0.015}$ | $\frac{8000}{0.015}$ |

A_i is limited to a maximum of 10 dB.

$$A_{\text{misc}} = A_i + A_f$$

3.13 Reflections

Reflections from vertical surfaces are handled automatically as image sources when they are selected in the set-up of barriers and in the project runtime file. Only first reflections from any surface are considered.

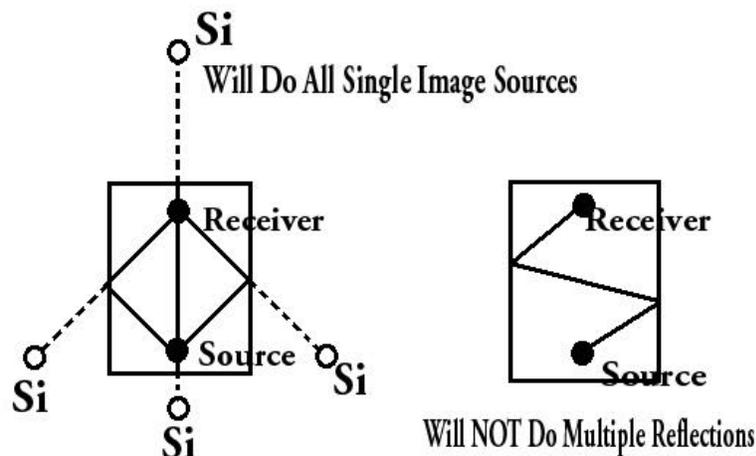
The first reflection limitation of SPM9613 was done for the following reasons:

1. Improved calculation speed. If multiple reflections are to be calculated, it must be accomplished by incrementing search rays within a grid system. This can cause time concerns since the search rays need to be quite fine to converge at the receiver.
2. Most outdoor noise sources are not in highly reflective environments. Usually, if the source or receiver is located near a building, enclosure or wall, it's reflection from that surface is the main concern. These are modeled adequately with the first reflections.
3. After each reflection, energy is lost and the distance between reflections becomes larger, significantly reducing the secondary reflections strength.

NOTE: Other important image sources from secondary reflections must be handled independently as separate noise sources. These must be manually entered by the user. Your failure to include important secondary reflections as separate manually entered noise sources can result in underestimating the sound levels.

Cylindrical objects are not part of the model nor are reflections from horizontal surfaces. ***Horizontal surface reflections can, however, be implemented manually as separate sources defined by the user.***

Examples of the reflections considered (and not considered) are shown below:



The reflection is calculated by:

$$L_{W_{\text{pointimage}}} = L_{W_{\text{point}}} + 10\log_{10}(\rho)$$

where

ρ is the reflection coefficient = (1 - absorption coeff)

The obstacle is considered large enough to be a reflector when octave band center frequency f_c is greater than the relation shown below:

$$f_c > \{2c/(l_{\min}\cos(\beta))^2\} \{(d_{s,o} d_{o,r})/(d_{s,o} + d_{o,r})\}$$

where

| | |
|------------|---|
| c | is the speed of sound, in meters per second |
| β | is the angle of incidence |
| $d_{s,o}$ | is the distance from the source to the obstacle |
| $d_{o,r}$ | is the distance from the obstacle to receiver |
| l_{\min} | is the minimum length of the reflecting surface |

The calculation follows the following logic. An image source is created from the real source. The point of intersection with the reflector and the line connecting the image source to observer is found. The sound is propagated from the real source to the point of intersection on the reflector, accounting for barriers and other miscellaneous noise attenuation along the way. The sound is then propagated from the point of reflection to the receiver, again looking for barriers and other miscellaneous noise attenuation. All attenuation effects follow that of the reflected source to observer path. The directivity used is that in the direction of the intersection point with the obstacle.

3.14 Meteorological Correction (Cmeteo)

The Meteorological Correction (Cmeteo) is handled by a “calculator” to allow the user to estimate the long term average A-weighted noise level (LAT(LT)). While not built in to the SPM9613 program as a feature to be calculated automatically for all observers, it can easily be handled with the calculator provided in the menu bar in the main project form. The value of Cmeteo can then be applied to the time averaged downwind A-weighted sound level.

The values of Cmeteo are calculated as follows:

$$C_{\text{meteo}} = 0, \quad \text{for } dp \leq 10(hs + hr)$$

$$C_{\text{meteo}} = Co(1-10(hs + hr)/dp), \quad \text{for } dp > 10(hs + hr)$$

where hs , and dp are based on the coordinates of the **dominant source** at the particular observer location.

hs , hr and dp are defined in the **Ground Effects** section of this document.

The value of Co is based on the percentage of time over a period of several months or a year the sound may propagate favorably in the direction of an observer. Co can be estimated from the local meteorological data. If the conditions for sound propagation are found to be favorable 50% of the time, a value of 3 (dB) would be used for Co . If the conditions are found to be favorable 33% of the time, a value of 4.8 (dB) would be used. For more information, reference ISO 9613-2

4.0 Operational Parameters and Guidelines

The pages that follow define the operational parameters of SPM9613.

4.1 Maximum Number Of Sources, Barriers Etc.

Sources - 200

Barriers - 200

Industrial Sites And Foliage - 200

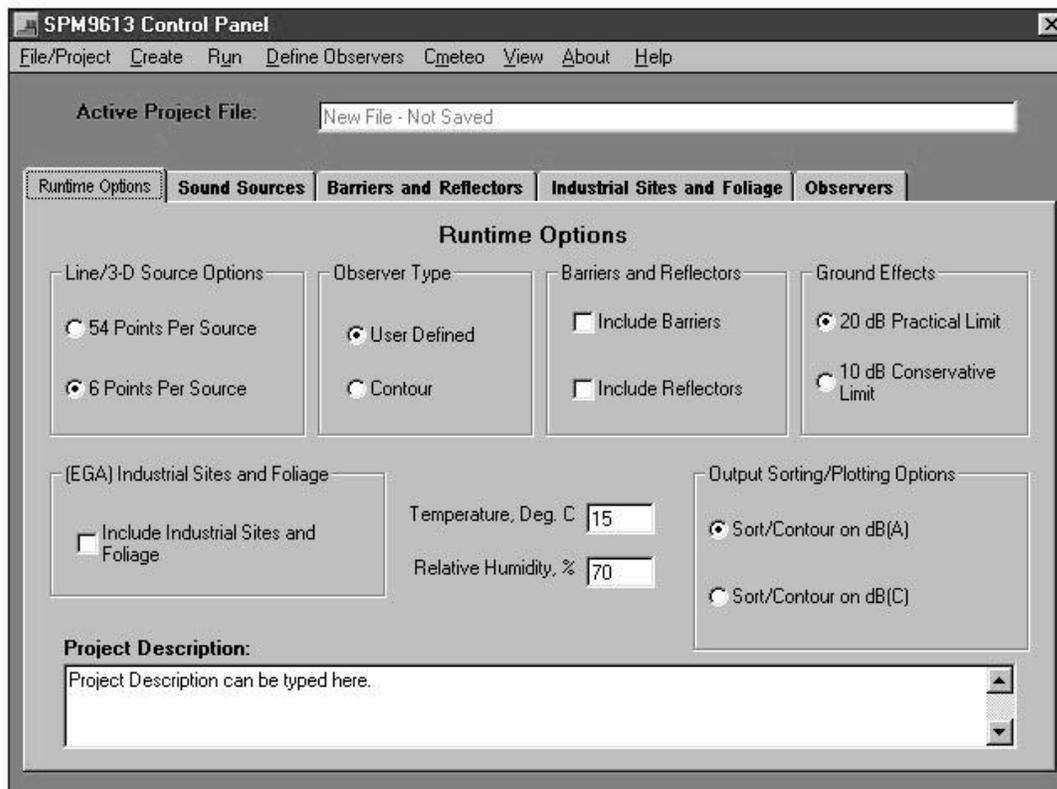
Observers (Per Run) - 48

Contour Observers (Per Run) - 121

4.2 Control Panel

The control panel is set up to allow the user to define a project. The user can add noise sources, barriers and reflectors, industrial sites and foliage effects, and observers.

The control panel is broken down into “File Tabs” and Menu Options. The menu options are located on the top of the screen like other Windows programs, and file tabs allow the user to quickly see the sources, barriers, observers, etc. that he has included in the project.



4.2.1 Menu Options

The menu options and sub-menu options perform the following:

File/Project

- New* - Starts a new project file or clears the existing project screen.
- Open* - Opens a project you have previously saved.
- Save* - Saves the project you are working on.
- SaveAs* - Saves the project as a different name.
- Exit* - Terminates the program.

Create

- Noise Sources* - Enters the Source input form to create new noise sources.
- Barriers* - Enters the Barrier/Reflector input form to create new barriers or reflectors.
- Industrial Sites and Foliage* - Enters the Industrial Site/Foliage form to create input data.

Run

- Calculate* - Begins the calculation (number crunching).
- Review Previous Calculation* - Reviews the output of your last calculation.
- Terminate Program* - Terminates the program.

Define Observers

- Contour* - Enters the input form to create a contour plot information, ranges, elevations, ground hardness, etc.
- User Defined Points* - Enters the input form to create individual observer points (x,y,z) etc.

Cmeteo Provides the user with a calculator to estimate long term environmental effects.

View View will allow the user to see plan views of the following:

- Sources and Barriers and Reflectors*
- Observers, Sources and Barriers and Reflectors, Foliage and Industrial Sites*
- Contour Points, Sources and Barriers and Reflectors, Foliage and Industrial Sites*

The plan view will be representative of files (sources, barriers, etc.) selected in the project as well as the Runtime Options selected. If barriers and reflectors are shutoff in the Runtime Options, they will not show up in the plan view representation regardless of whether files are included in the Barriers and Reflectors Tab. This is also true with the Industrial Sites and Foliage Runtime Option.

About Provides information about the company

Help Provides information on:

- Runtime Options*
- Sound Sources*
- Barriers and Reflectors*
- Observers*
- Industrial Sites and Foliage*

4.2.2 File Tabs

The available project File Tabs are as follows:

Runtime Options
Sound Sources
Barriers and Reflectors
Industrial Sites and Foliage
Observers

By selecting a File Tab you will be able to see what options have been selected (Runtime Options Tab) or what files (source files, barriers, etc.) have been included in the project.

Runtime Options Tab

The Runtime Options include:

Line/3-D Source Options, Observer Type, Barrier and Reflector Options, Ground Effect Limits, Industrial Sites or Foliage Options, Temperature and Relative Humidity, Sorting Options and Project Description text.

Line/3-D Source Options - allows the user to select the level of source resolution if the source has been defined as a line or three dimensional source. The user can select 6 or 54 point representations. For quicker but less accurate calculations, the 6 point representation should be selected.

Observer Type - determines if a contour calculation will be run from a contour file or individual specific point observers from a user defined file.

Barrier and Reflection Options - allows the user to turn barrier effects and reflector effects on or off. This option will override the inclusion of barrier or reflector files.

Ground Effect Limits - sets the limits on the amount of attenuation allowed by the Ground Effect. Limits are relative to "Hard Ground".

Industrial Sites and Foliage - allows the user to turn on or off the industrial sites and foliage attenuation effects. This option will override whether or not industrial site or foliage files have been included in the project.

Temperature and Relative Humidity - allows the user to set the temperature (in degrees C) and relative humidity (in percent). This options will effect the calculation of atmospheric absorption and various other wavelength related phenomena.

Sorting Options - allows the user to sort/rank the source strength output by A-weighted or C-weighted levels. This option also determines whether an A-weighted or C-weighted contour plot will be displayed (if the contour option has been selected.)

Project Description - allows the user to add a text description of the project.

Sound Sources Tab
Barriers and Reflectors Tab
Industrial Sites and Foliage Tab

The above Project Tabs have three functions:

1. Allow the user to view what files are included in the project.
2. Allow the user to add files previously defined with other projects or other SPM9613 user sessions.
3. Allow the user to remove files from the project.

A list box will show all of the files currently defined in the project you've opened. If the user double clicks on the file shown in the list, it will open the file and allow the data to be viewed or modified.

A control button, "Add User Defined ... To Project" allows the user to place additional files into the project without creating them through the "Create Menu". The files may be from previously defined projects or previous SPM9613 user sessions where the files have not been assigned to a project. The user can then reuse files he has previously created. A dialog box is displayed that prompts the user to select the file to be added.

A control button, "Remove ... From Project" allows the user to remove a file from the current project. This can be accomplished by highlighting the file with the mouse, then clicking on the "Remove Button".

NOTE: While the file will be removed from the project it WILL NOT BE DELETED. It can later be added back to the project with the Add Button if necessary.

Observers Tab

The above Observer Tabs have two functions:

1. Allows the user to view what files are included in the project.
2. Allow the user to add files previously defined with other projects or other SPM9613 user sessions.

A list box will show the contour file or observer file currently defined in the project you've opened. If the user double clicks on the file shown in the list, it will open the file and allow the data to be viewed or modified.

A control button, "Add User Defined Contour File or Observer File To Project" allows the user to add or replace the file contour or observer file into the project without creating them through the "Create Menu". The files may be from previously defined projects or previous SPM9613 user sessions where the files have not been assigned to a project. The user can then reuse files he has previously created. A dialog box is displayed that prompts the user to select the file to be added.

It should be noted that only one contour and one observer file is allowed. If the user asks to add a new file he will be prompted to replace the existing project file. Replacing the existing project file will remove the file from the current project but it WILL NOT BE DELETED. It can be added back later by selecting the "Add User Defined Contour File or Observer File To Project" Control Button.

Whether the Contour file or the Observer file is used in the calculation is determined in the Runtime Options Tab.

4.3 Sound Source Definition Form

The sound source entry form is set up to allow the user to define a sound source. He can enter this form by either clicking on the “Create” menu item on the Control Panel or by double clicking on a valid file shown in the appropriate List Box in the Project Tabs.

The form is broken down into data entry and Menu Options. The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.

4.3.1 Menu Options

The menu options and sub-menu options perform the following:

File

- New* - Starts a new file or clears the existing screen.
- Open* - Opens a file you have previously saved.
- Save* - Saves the file you are working on.
- SaveAs* - Saves the file as a different name.
- Printer Font* - Sets the font data will be printed in.
- Print* - Prints a summary of the data input.
- Close* - Exits the entry form.

Directivity - Selects the form for directivity data entry

- In xy Plane* - in the xy plane.
- Z axis* - about the z-axis.

Data are input in 10 degree increments from 0 to 350 degrees, in the xy plane and 0 to 180 degrees about the z axis. A Directivity sub-menu allows the directivity data to be viewed. Angle references can be found in the Technical Section.

Sides - Selects the side of a three dimensional source to be included in the representation of the 3 dimensional source. Six sides can exist on a 3-D sound source (four sides and upper/lower surfaces). A check mark next to the side will indicate the side **is not included**. This is useful when modeling stretches of connecting ducting or single planar surfaces.

Ground - Selects the form for ground elevation and ground hardness data entry.

Help - Provides on-line help.

View - Provides a plan view and elevation “bar”.

4.3.2 Sound Source Data Entry

The data indicated on the Sound Source Definition Form are mandatory. It includes: Sound Power Level information, source coordinates, a source description, and the type of source (line, 3-D, or point).

Other information, such as directivity, side or ground information are not mandatory and will take on default values. The directivity defaults to omni-directional. The side information defaults to all sides included. The Ground Elevation and Ground Hardness defaults to an elevation of zero and hard ground (0).

The x, y and z information is required for four corners for both point sources and 3-D sources. Although a point source is not 3-dimensional, this information is necessary for “plan view” viewing purposes and

for directivity reference points. If line sources are selected, only the {x1,y1}, {x2,y2} and {zlower} points will allow data input. Line sources are assumed to be omni-directional. See the Technical Section for source definition information.

Each of the four corner points must be entered in a clockwise direction for the directivity information to be handled correctly. x2,y2 must follow x1,y1 as viewed in the plan view as rotating clockwise around the source. Similarly, x3,y3 must follow x2,y2 as viewed in the plan view as rotating clockwise around the source, etc.

4.4 Barrier Definition Form

The barrier entry form is set up to allow the user to define a barrier or reflector. He can enter this form by either clicking on the “Create” menu item on the Control Panel or by double clicking on a valid file shown in the appropriate List Box in the Project Tabs.

The form is broken down into data entry and Menu Options. The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.

4.4.1 Menu Options

The menu options and sub-menu options perform the following:

File

- New* - Starts a new file or clears the existing screen.
- Open* - Opens a file you have previously saved.
- Save* - Saves the file you are working on.
- SaveAs* - Saves the file as a different name.
- Printer Font* - Sets the font data will be printed in.
- Print* - Prints a summary of the data input.
- Close* - Exits the entry form.

Leakage - Allows the selection of sound “leakage” around a barriers vertical edge. This is useful when two or more barriers adjoin.

View - Provides a plan view and elevation “bar”.

Help - Provides on-line help.

4.4.2 Barrier Data Entry

The data indicated on the Barrier/Reflector Definition Form are mandatory. It includes: coordinates, a description, barrier or reflector type and reflection coefficients. Reflection coefficients of 1 (fully reflective) are the default.

Other information, such as leakage, is not mandatory and will take on default values. The default value for side (edge leakage) is sound is allowed to leak around the barrier’s edge.

4.5 Industrial Sites And Foliage Definition Form

The industrial site and foliage entry form is set up to allow the user to define a attenuation from an industrial site or foliage. He can enter this form by either clicking on the “Create” menu item on the Control Panel or by double clicking on a valid file shown in the appropriate List Box in the Project Tabs.

The form is broken down into data entry and Menu Options. The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.

4.5.1 Menu Options

The menu options and sub-menu options perform the following:

File

- New* - Starts a new file or clears the existing screen.
- Open* - Opens a file you have previously saved.
- Save* - Saves the file you are working on.
- SaveAs* - Saves the file as a different name.
- Printer Font* - Sets the font data will be printed in.
- Print* - Prints a summary of the data input.
- Close* - Exits the entry form.

View - Provides a plan view and elevation “bar”.

Help - Provides on-line help.

4.5.2 Industrial Site and Foliage Data Entry

The data indicated on the Industrial Site and Foliage Definition Form are mandatory. It includes: coordinates, a description, Industrial Site or Foliage indicator.

The coordinates defining the industrial sites or foliage can be irregular in shape. However, no lines defining the industrial site of foliage area must cross when viewed in the plan view.

4.6 Contour Data Definition Form

The contour data entry form is set up to allow the user to define a range of x-y values he wishes to perform contour calculations on. The program breaks down the grid to an 11x11 map and allows the user to put in information about the ground elevation and hardness. He can enter this form by either clicking on the “Define Observers” menu item on the Control Panel or by double clicking on a valid file shown in the appropriate List Box in the Project Tabs.

The form is broken down into data entry and Menu Options. The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.

4.6.1 Menu Options

The menu options and sub-menu options perform the following:

File

- Open* - Opens a file you have previously saved.

Save - Saves the file you are working on.
SaveAs - Saves the file as a different name.
Printer Font - Sets the font data will be printed in.
Print - Prints a summary of the data input.
Close - Exits the entry form.

Ground Characteristics - Allows user to define the ground type and elevation.
Set Ground Elevation - Defines the elevation on the 11x11 grid points.
View - Provides a 3-D view of the ground elevation
Set Ground Hardness - Defines the ground hardness on the 11x11 grid points.
View - Provides a Contour view of the ground hardness

4.6.2 Contour Data Control Entry

The data indicated on the Contour Data Control Definition Form are mandatory. It includes: minimum and maximum coordinates of the desired plotting range, a description and an average observer height above the ground.

Default values for ground hardness are 0 (hard ground), and 0 meters ground elevation.

4.7 User Defined Observer Points Definition Form

The user defined observer locations data entry form is set up to allow the user to define individual x-y and elevation values he wishes to perform specific point calculations on. The form allows the user to add information about the ground elevation and hardness at the observer and at the middle ground area. He can enter this form by either clicking on the "Define Observers" menu item on the Control Panel or by double clicking on a valid file shown in the appropriate List Box in the Project Tabs.

The form is broken down into data entry and Menu Options. The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.

4.7.1 Menu Options

The menu options and sub-menu options perform the following:

File

Open - Opens a file you have previously saved.
Save - Saves the file you are working on.
SaveAs - Saves the file as a different name.
Printer Font - Sets the font data will be printed in.
Print - Prints a summary of the data input.
Close - Exits the entry form.

Page 2 - Allows user to define the specific observers, 13 to 24.

Page 3 - Allows user to define the specific observers, 25 to 36.

Page 4 - Allows user to define the specific observers, 37 to 48.

Help - Provides on-line help.

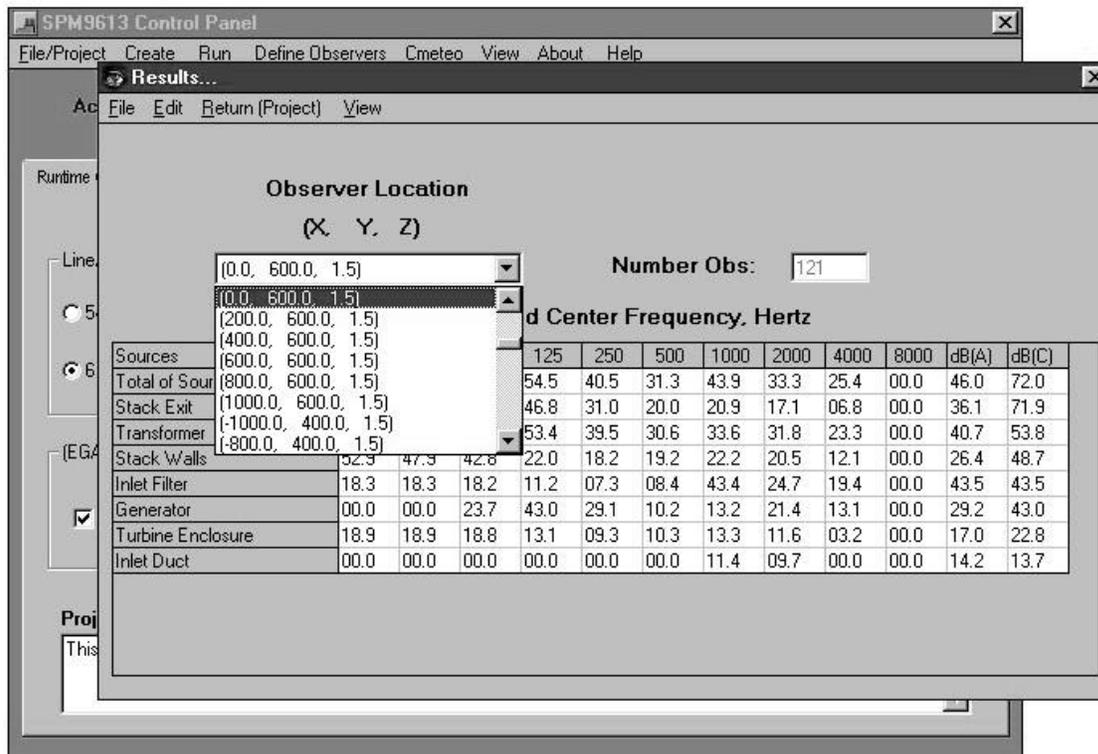
4.7.2 Observer Form Data Control Entry

The data indicated on the Observer Data Control Definition Form are mandatory. It includes: x, y and z coordinates of the receiver, the ground elevation and hardness of the receiver and the middle ground hardness, a description and an average observer height above the ground. The box location near the observer must be checked for the observer to be included in the calculation.

4.8 Results Form

The results form is set up to allow the user to view the individual noise calculations at each x,y,z observer location. This is accomplished by clicking on the arrow near the list box and highlighting the coordinate that you wish to view. The data shown will be sorted by source (maximum to minimum) on A or C weighted values as determined by the selection on the Project Control Panel.

The menu options are located on the top of the screen in a similar fashion to other Windows programs. The Menu Options generally provide other means to view or enter more data.



4.8.1 Menu Options

The menu options and sub-menu options perform the following:

File

Printer Font - Sets the font data will be printed in.

Print - Prints a summary of the data input.

Edit

- Allows the user to copy the output data into other applications. This is accomplished by highlighting (left mouse button) items the user wishes to copy, then selecting "copy". The data can then be pasted into other Windows applications.

Return - Returns the user to the main Project Control Panel.

View

- Allows user to view data.

Contour - Contour plot of data (if project contour calculation was selected)

Sources - Sound Spectra are shown in waterfall plots for the 10 highest ranked sources.

4.8.2 Displayed Results

All octave band sound pressure levels and A-weighted and C-weighted sound levels calculated to be less than 0 dB are displayed as 0 dB. As an example, a value calculated to be -10 dB will appear on the display and printout as 0 dB.

The A-weighted and C-weighted sound levels, however, are *calculated prior* to the octave band sound pressure levels being set to the display limit of 0 dB.

4.8.3 Contour Plots

Within the Contour Plot, the user can print the plot, view and transport the data that made up the plot into other applications.

Selecting the data menu option will provide a listing of the data used to develop the plot. It can be highlighted using the mouse and copied on to the clipboard by either using the edit menu option or by right clicking on the mouse and selecting the appropriate item.

4.9 Example Of Project (Samples)

Samples must be in the directory “C:\SPM9613 for them to work correctly. This will automatically be performed for you if you’ve allowed the program to install itself in the default directory.

After installing the samples from the CD-ROM to your C: drive, perform the following:

In the project control panel file, go to File and Open.

Be sure you are in C:\SPM9613.

If you’ve correctly loaded the program to it’s default directory, the sample files will be showing you “econ1.prj”, “line.prj”, and “pointe33.prj”.

Highlight the econ1.prj file and double click or click on the open button.

It will show a list of files for the “Project” when you click on the Source, Barrier, Industrial Site and Foliage, or Observer file tabs.

You can look at the project input by clicking on “**View**” while in the **Project Control Panel** form. The equipment layout can be viewed as well as observers and contour observer points.

After viewing the project, go to the “Source” Tab, double click on stack exit. You can “**View**” the coordinates and the spectrum. While still in the Source Definition form, click the directivity menu item and select “**Z-axis**”. You can “**view**” the directivity information.

Try doing similar things with the Barriers and Foliage.

Now click on the “observers” tab and double click on the contour File. It will show you the coordinates you’ve defined for the contour. You can look at the ground elevation and hardness by clicking on “Contour Ground Characteristics”. Now you can view the elevation (surface plot) or hardness (Contour).

You can also view the observers file (individually user selected observers) by double clicking on it. These are user selected data points (not contour points.) A check mark indicates the calculation will include the “Observer”. Removing the check mark will cause the calculation to bypass that specific data point.

4.9.1 Running

You can run the program by clicking on Run. After you’ve run your first calculation, you can view it later (the output is automatically saved from the last run) .

You can “view” the composite source spectra for each observer or the contour plot. The observer that you view can be selected by the drop down list box showing the coordinates of the observer. If you’ve run a contour calculation, you can view the contour plot. The contour data can be found in the file item marked “data”. The data can be copied into other applications or contouring programs.

4.9.2 Plot Screen Resolution

In some cases, the text resolution of the various three dimensional plots shown on your computer’s monitor may not be readable. The printed versions of the plots, however, will be significantly improved. On high resolution printers, the plots will be presentation quality.

5.0 Support Policy and Upgrades

To provide SPM9613 on a cost effective basis, free support is limited to 30 minutes for each licensed copy. This should adequately allow you to get the program operational on your PC.

Additional support will be billed at the consultant's standard hourly rate.

Bugs found by the user that are well documented with hand calculations and/or systematic running of the program will be supported free of charge and corrected at the soonest possible time.

User's of SPM9613 Version 1 are entitled to free upgrades to Version 1 from the internet site. Details of downloading upgrades will be provided upon purchase of software.

6.0 Software Protection Keys (HASP keys)

Runtime operation of SPM9613 is protected by a hardware key. Without the key attached to your computer's parallel port, the program will go into a demo mode. The demo mode does not allow the user to save noise source files and limits the number of days SPM9613 can be used or number of runs to 30.

A hardware driver must be installed to allow the HASP key to be recognized by your computer. If you have not loaded the driver, enter the HASPDrv directory (file folder) on the SPM9613 CDROM. Find the setup.exe file and execute it by double clicking on it.

Provided the SPM9613 CDROM version (not the internet version) has been loaded on your computer, installing the HASP key along with the necessary driver (software) will eliminate any access problems and provide full functionality of the SPM9613 program.

7.0 Replacement Policy

HASP Keys

Protect Your Key!!!!!! It is valuable.

Damaged or inoperable HASP hardware keys **must be returned to Power Acoustics, Inc. for replacement.**

You must call Power Acoustics, Inc. before returning keys. Lost or stolen keys or keys not received by Power Acoustics, Inc. in return shipment can be replaced at the full purchase price.

Keys returned within 30 days of purchase, will be replaced free of charge.

Lost or stolen keys can be replaced at the full purchase price.

CDROM

Damaged or inoperable CDROMs will be replaced for free within 30 days of purchase. It is your responsibility to make a backup copy for your own use.