Chapter V
Conclusion and Recommendation

5.1 Conclusion

To illustrate the accuracy levels of the power plant noise prediction model. Sound Pressure Level (SPL) measurements were conducted during dry season on 29th November to 3rd December in 1995 and 18th to 21st March in 1996. Mathematical structure can explain the notable functions in terms of Sound Power Level (PWL) of noise sources and the transfer functions. The most significant transfer function, considered by this study, was the divergence attenuation. This correction was larger than the other corrections particularly in short distance. (1 to 500 meters)

Rayong Power Plant (RPP) was the suitable and applicable site to verify the prediction model because it is not interfered by other noise sources due to its isolated location. It has almost all types of industrial sound sources. This study concerned input part of the model in two main terms; emission and transmission. The author considered those sound sources in 2 main groups; point source and non-point source. To determine the PWL of sound source, the SPL measurement was taken following ISO1996/1, ISO3746, and the equal angle method for both source types, exclusively point source types and exclusively non-point source types respectively.

The Colenbrander, solid surface, linear surface and area surface methods were selectively used for non-point sources PWL determination depending on an appropriate condition in each case. The small sources located outside the main buildings were determined by the point source equation. The considered noise sources were cooling towers, main buildings, electric pumps, air inlets, electric motors, cooling fin fans, air compressors and opening shutters of the main building. Müller's equation, decibel addition concept and ray-tracing technique were used to select the considering sound sources. The selected noise sources in the prediction model were cooling towers and main buildings. The Colenbrander's method and area surface method were used for the determination of both main sources respectively.

Each transmission path was considered as a combination of on-site transfer functions namely divergence attenuation, air absorption attenuation, ground effect, attenuation by reflecting obstacle and attenuation by screening obstacle. Divergence attenuation, air absorption attenuation, and ground effect correction were considered as the major transfer functions in this prediction model. The air absorption attenuation needs the in situ air temperature and relative humidity for the transmission data input part of the model. The applicable conditions for air absorption attenuation should be in the ranges of 0 °C to 45 °C of temperature and 10 to 100 % relative humidity. The screening and reflecting obstacles were left as an optional parameters for the similar prediction. They were excluded from this study because of the complicated identification of the obstacles and transmission paths.

Sound propagation outdoor equation, the general equation for noise prediction, is applicable to the noise prediction model of combine cycle power plant at RPP. This mathematical model was a deterministic model applying to power plant noise prediction. A computer software technique was introduced to facilitate the calculations of the complicated equations. The author developed a software called "Sonic" using Visual Basic programming language version 3.0 runs on MS windows 3.11, to handle all the calculations in the study. This software can calculate the PWL of noise sources by inputting measured SPL values and PWL values provided by machine manufacturers. The sonic was also designed in an user friendly manner.

The noise from cooling towers were generated by driven motors, propeller fans, water pumps, and water splashing. Müller's equation was introduced to predict PWL in this study to ensure the significance of error due to different calculation methods used. The designed PWL were not provided by RPP. PWL of all machines operated in mechanical induced draft cooling tower as calculated by Müller's equation and by Colenbrander's method, were 115.9 decibels and 116.7 decibels respectively.

Almost all of the major noise sources in the plant, i.e. turbines, condensers, feeding pumps, combustion chambers, are located in the main buildings. Those buildings are enclosed by enclosure walls. To ease the measurement procedure, the author decided to divide the main buildings into 3 zones; left,right, and center. The outdoor SPL measurements were conducted zone by zone consecutively. The area surface method was used for PWL calculation and determination in this case. The calculated PWL were 114.7, 112.9, and 118.2 decibels at left zone, right zone, and central zone respectively.

The results of noise levels in operation areas of RPP were completely under the noise limit at work both inside and outside the main buildings except the noise levels were around the condensers inside the main building. Otherwise RPP's operators will be in the control room where enclosed with the protection noise material. RPP has also an ear protection sign at the possible polluted areas.

To determine the accuracy of the model, the SPL at noise immissions were measured. The 115 measurement positions within the vicinity of 16 defined significant noise sources were set out with 255 transmission paths to be considered. The actual SPL measurements at noise immissions were conducted together with the collections of related transmission path data. Then the transmission path data were calculated with measured PWL in order to illustrated the predicted SPL from the model.

Those predicted SPL values were used to compare with on-site SPL values measured. The comparison led to the illustration of acceptable accuracy level of this model. The author, then, plotted the correlation graphs between measured SPL(x) and predicted SPL(y). Figure 4-16 to 4-19 showed the scattered correlation along with ideal equivalent line. When considering plots beyond ± 10 decibels range, we found that most of those data came from the positions adjacent to other sources not considered in the model.

We also found that the measured SPL values of the upwind stations were lower than predicted SPL values of the same stations. It meant that the location of the measuring stations had some influences on the calculation. The directivity of noise source, depending on the source location and its environment, had some effect on the calculation also. The author plotted the last correlation graph which excluding the data from small noise sources and upwind zone stations but including the determination of directivity index. After eliminated the improper data and added transfer corrections in order to explain the accuracy of the prediction model, there were only 50.6 % of data were within ± 5 decibels accuracy level.

5.2 Recommendation

There were three obstacles during the development of power plant noise prediction model. PWL of machines and acoustical specification of the enclosure wall used in RPP was not available, the limitation of sampling instrument to determine PWL, and the limitation and complication of some data required. The author decided to use the ordinary Sound Level Meter (SLM) with octave band filter set type I to handle all of the sampling in this study. The frequency analyzer only use for the same case as normal SLM and octave filter set with the same acoustic calibrated levels to justify the accuracy level of the prediction model. Meanwhile the measurement was taken place, some important measurement point cannot be measured in RPP because it is dangerous to reach such as higher point near the electrical power line. Therefore, noise measurement for the verification of noise prediction model need more supplement equipment to facilitate the measurement such as intensity probe and calibrator, mobile man lift, portable frequency analyzer, noise speaker, digital recorder tape, and so on.

From this study, the author recommended the further study of the development of industrial noise prediction model. Necessary actions should be concerned according to followings.

1. The compilation of PWL database of machines that is popularly used in factory in Thailand. It should be conducted by the government authority.
2. The compilation of sound transmission loss and absorption coefficient database of enclosure material that is ordinarily used in factory in Thailand. It should also be conducted by the government authority.
3. Indoor SPL measurement method should use reverberation time technique to determine PWL of machines.
4. The study of correction function of the multi-screening obstacle source and reflecting obstacle source in case of industrial area should be concerned to improve the prediction model.
5. The study of shadow zone attenuation correction in case of normal wind speed and direction with temperature gradient in Thailand should be concerned for the further study of this prediction model particularly in windy area.

The input technique of the sonic software should be improved to facilitate the user friendly of the prediction model. Grid-system (X-Y-Z coordinate) should be introduced to improve the input system handling the delicate data in the Sonic software. The author recommended the using of database or spreadsheet software. (e.g. MS Access, MS Excel for windows 3.11) to complete this suggestion in the programming design. The advantage and the limitation of Sonic software summarized as:

Table 5-1 The advantage and Limitation of the Sonic Software

Advantage	1	It can calculate PWL of point source from SPL measurement depending on the guidance of ISO 3746 in outdoor conditions.
	2	It can calculate PWL of non-point source by forth options of SPL measurement using equal angle methods. (Linear surface method, Area surface method, Solid surface method and Colenbrander's method)
	3	It can use PWL in items 1 and 2 in order to be the input data of the prediction model predicting the SPL at any immission point in the vicinity of sources in outdoor condition.
	4	It can use PWL from database's machines or other determinations such as stüber method to predict noise level at any immission point in outdoor conditions.
	5	It can predict noise levels at any immission point under the proposed transmission path conditions.
	6	It can read and write the calculated PWL data and SPL predicted data into normal text file or ascii format.
	7	It has friendly user screen input module.
Limitation	1	It can accept only non-grid system input data.
	2	It supports only text input and output format.
	3	File input facility is available for PWL calculation only.
	4	It require the complicated data from observation and measurement of input parameter controlling by the number of transmission paths.
	5	The accuracy is ± 5 decibels in downwind condition and less accuracy in upwind condition.

Ray-tracing technique or grid-system method can use for making isointensity map to determine PWL and directivity of sound source. It can also make the noise contour map of industrial areas using SPL measurement in one minute at node of rectangular grid-box. According to this technique, the contour map can show two information; sound pattern or directivity pattern and location of source. These information is necessary for noise pollution control in factories. The measured contour map presents the location of sound sources and its directional tendency with actual iso-noise level lines. It can be used to identify areas that have sound levels exceed the regulated limit of working noise condition. The employers must be forced to install the warning sign to wear an ear protection equipment at those identified areas.

Noise contour map can also support the noise control management inside operation areas of factories and environmental noise control. Node of high levels can indicate the location of machines that need noise improvement control. The isoline can present the practicable polluted areas outside or inside the operation areas. Besides noise map can indicate the broken or unusual function of machines. According to this measurement method, noise contour map was very useful for both employers and government inspectors to control environmental noise pollution from industrial areas the noise regulations at work place or industrial areas.