Goldboro LNG

CB&I **Pieridae Energy Limited**

Document Title: **Noise Study**

Document No: **185352-000-ME-RP-00001**

Revision: **C**

Issue Date: **17-12-2013**

CB&I Contract No: **185352**

Revision Descriptions	Rev	Date	Originator	Checker	Approver
Issued for Use	A	31-01-2013	DJW	DAR	MW
Issued for Use	B	13-12-2013	RB	DJW	RDB
Issued for Use	C	17-12-2013	RB	DJW	RDB

INPUTS / REFERENCE DOCUMENTS

Document Number	Title	Status
	Keltic Petrochemical and Liquefied Natural Gas Facility Impact Assessment	2006-2007
	Health Canada, Environmental Health Program, Regions and Programs Bureau, Letter to Helen Yeh, Environmental Assessment Branch dated 9th December 2013	

REVISION NOTES AND HOLDS

Revision	Description of Changes & Holds	
A	Issued for Use	
B	Issued for use including comments from Health Canada Added conclusion, noise level prediction contours and noise modelling parameters including input data (Section 8).	
C	Issued for use including comments from AMEC	
HOLDS	Description of Holds	Rev Date
1	Deleted	
2	Deleted	
3	Finalised Equipment Layout	
4	Environmental Receptors	
5	Winterisation - extend of clad Modules	
6	Deleted	

Table of Contents

Contents **Page**

1.0 INTRODUCTION

Pieridae Energy Ltd is planning to construct a natural gas liquefaction, storage and export facility at the Goldboro Industrial Park in Guysborough County, Nova Scotia, an I-3 designated industrial area. The facility will ultimately be able to produce up to 10 Million Tonnes per annum of liquefied natural gas (LNG) for export to the global LNG market, nominally Europe, South America and Asia. The desire to construct an LNG export terminal has arisen as a result of the unconventional gas reserves coming on stream in Canada and North Eastern USA.

Gas will be fed to the facility from the existing Maritimes & Northeast Pipeline (M&NP), via a short tie-in pipeline that will follow the route of the Sable Offshore inlet pipeline that runs between the two facilities.

The Goldboro LNG Project (the Project) will be designed for total LNG storage of up to 690,000m^3 in three full containment, atmospheric storage tanks for export via a marine loading facility comprising a jetty and two berths located off of the Dung Cove headland in Stormont Bay. The marine works will also include a wharf to provide protection for tug boats as well as providing access for materials during the construction phase of the project.

2.0 SCOPE

This document provides a preliminary high level prediction of noise emissions for the Project, a review of applicable regulatory requirements, and noise abatement measures and options for the Project. The study's preliminary noise level predictions include noise levels at locations both inside and outside of the facility's site boundary.

3.0 REFERENCES, CODES AND STANDARDS

The design for noise control shall be in accordance with the valid editions of the applicable National and/ or International Codes and Standards. All Canadian national legal and regulatory standards require to be adhered to as well as the specific requirements and conditions of the provincial and local regulations from Nova Scotia and Guysborough County. Where a conflict between the codes, etc., might exist, the most stringent requirements shall take precedence.

Lists identified below should not be considered exhaustive.

3.1 Codes and Standards

Ref.	Document Number	Document Title
1	SOR/86-304	Canada Occupational Health and Safety Regulations
2	O.I.C. 76-1510, N.S. Reg. 112/76	Nova Scotia Occupational Health Regulations
3	ISO 9613-2	Acoustics – Propagation of Sound During Propagation Outdoors – Part 2: General Method of Calculation
4		Nova Scotia Department of Environment, Guideline for Environmental Noise Measurement and Assessment

4.0 DEFINITIONS

Refer to Appendix 2 for Noise Control Definitions

5.0 NOISE LIMITS

5.1 Occupational Health Limit

5.1.1 General

The Canada Occupational Health and Safety Regulations (Ref. 1) provide the main framework for the approach to noise control in Canada and sets high level occupational health noise limits to protect workers in Canada. The Provincial Regulations in effect in Nova Scotia (Ref. 2) take precedence over the National Regulations.

On inspection of these documents, it is deemed that the approach to occupational noise control shall comply with the national regulations requirements and that the occupational noise limits shall comply with the Provincial Regulations. The Regulations for Nova Scotia refer to the Threshold Limit Values published by the American Conference of Governmental Industrial Hygienists (ACGIH).

5.1.2 Normal Work Limit

ACGIH Dose is for a noise exposure equivalent to 85dB(A) for 8hrs. The threshold for action is noise levels of 80dB(A). See Appendix 1 for further details.

5.1.3 Max Allowable Noise

The maximum sound pressure level is 140dB(Peak), it is not permissible to expose personnel to sound levels that exceed this, see Appendix 1 for further details. For information, 140dB(Peak) corresponds to approximately 115dB(A).

5.2 Area Noise Limit

In order to control occupational noise exposure, area noise limits should be applied. Typically, these are in accordance with the following table.

Area	Typical Noise Level Limits - dB(A)
Outdoor Equipment Areas	85
Indoor Equipment Areas	85
Workshops	75
E&I Equipment Room	65 (Note 1)
Control Room	55
Offices	50
Note 1: 65dB(A) only applies in areas where there is a permanent workstation. In other areas, or unmanned room, 85dB(A) applies.	

5.3 Environmental Limits

Nova Scotia Environment has established the following criteria under its Guideline for Environmental Noise Measurement and Assessment document:

- Day (0700 - 1900) 65dB(A)
- Evening (1900 - 2300) 60dB(A)
- Night (2300 - 0700) 55dB(A)

These noise criteria will be used for assessing receptor impact during the construction period and normal operation of the LNG facility.

Noise control and management measures (including a noise monitoring plan) will be developed as part of FEED and incorporated with the Project's Environmental Management Plan. The noise management plan will also include a mechanism for receiving and responding to public complaints and be subject to the proponent's on-going community notification and consultation.

6.0 NOISE SOURCES

6.1 Continuous Sources

Typical LNG liquefaction plants contain items of equipment that will cause high noise levels, either due to the equipment being noisy or due to the sheer number of units producing noise. Typically, the high noise sources include the large refrigeration compressor trains, the boil off gas compressors, the power generation gas turbine exhaust stack and some utility equipment such as cryogenic nitrogen generation plants and instrument air compressors. Fin fan air cooled heat exchangers tend not to be excessively noisy in their own right however there are typically large numbers of these unit types installed adjacent to each other which will combine to produce high noise levels on and off site.

6.2 Intermittent Sources

Intermittent sources tend to be noisier in nature but operate infrequently and for short durations. Emergency flaring and operation of pressure relief valves are examples of noise sources that will emit high noise levels which require to be considered during the design phase as they could potentially be a safety concern for on-site personnel and have an effect on environmental receptors.

6.3 Construction Sources

These include truck movements, earthworks, blasting, piling etc. These are not included in the noise modelling.

7.0 OFFSITE RECEPTORS

There are both residential and industrial receptors located within approx. 1km of the proposed site boundary. These are:

- Two residential properties (3 buildings)located around Webb's Cove approximately 200-400m to the west of the gas plant entrance (Sable Road)
- One residential property (1 building) located approx. 900m southeast of the plant boundary.
- Sable Offshore Energy Inc. (SOEI) Gas Plant approx. 400m north of the plant boundary

Further to these receptors, the towns of Goldboro (northwest) and Drum Head (east) are outside a 1km radius.

8.0 NOISE MODELLING

8.1 Software Parameters

The noise model was developed in SoundPLAN V7.2. The software uses sound power level as the input data which is then propagated to give sound pressure level predictions at all locations on a chosen surface or at a specific location. The input data is a sound power level which is the property of the equipment and the output shown on the noise contours is a sound pressure level which is the sound perceived by a receiver which decreases as the receiver travels away from the source.

The sound power level is radiated according to ISO 9613-2 referenced above. An absorption coefficient of 0.05 was used for the area within the site boundary and 0.9 was used for the areas outside of the site boundary. This is considered acceptable per ISO 9613 Part 2.

The noise model does not include background noise levels as it is typically only given at specific locations that are sensitive to noise. Background noise data and the cumulative effects of existing noise sources is to be evaluated separately during FEED, when the noise model will be refined and specific approaches to noise abatement are being developed.

8.2 Wind and Ambient Conditions

The noise modelling software assumes that the wind blows equally from all directions.

Ambient conditions used are: 10 °C with 70% relative humidity.

8.3 Grade Elevation

A grade elevation of MSL + 5m has been used for major noise producers such as the LNG trains and the gas turbine generators.

8.4 Input Noise Data

8.4.1 General

The noise data for the model is as tabled below. Each of the sources shown represents a point source that has been spatially arranged on the Plot Plan and an estimate of the elevation of the equipment above the ground.

8.4.2 Noise Model

Given the early stage of the Project, the noise model is a simplified model. The tabled noise data therefore does not represent an extensive list of sources that can be expected in a gas liquefaction plant. The simplification is two-fold: (1) only the main noise contributors for each area have been included, and (2) multiple sources (such as the air coolers) have been combined into fewer sources.

The simplified model is calibrated using the noise map produced by noise survey measurements of an operational site (APCI Process). The overall sound power level from the model is also compared to the design model for the same plant. This allows for the hundreds of air coolers to be acoustically combined into fewer, more powerful sources.

8.5 Sound Power Level Data

The following sound power level data is on a per train basis.

Source	L_w dB(A)	Comment
BOG Comp	105	In building
GTG x 5	115	Only exhaust modelled
Inlet Area	110	
Inlet Compressor	118	In building
N2 Package	118	In building
LP MR / MP MR Compressors	126	In building, compressor string combined into one source
HP MR / PR Compressors	126	In building, compressor string combined into one source
Pipe	115	
ACHE x 12	120	
ACHE x 12	118	
Comp GT x 2 (Exhaust)	118	
Comp GT x 2 (Air Inlet)	118	
Note: Data taken from previous LNG Liquefaction Project		

8.5.1 Sound Frequency

Noise modelling is based on the following octave band spectrum shape. The actual values used for each source are scaled up to meet the overall dBA value stated above.

Equipment Noise Data - dB(A)								
63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	Sum
73.8	78.9	84.4	86.8	89.0	91.2	86.0	73.9	95.3

It is of note that absorption by terrain and the atmosphere is more pronounced at higher frequencies.

8.5.2 Building Properties

The transmission loss used for the equipment buildings described above is tabled below.

	Sound Reduction Index (Rw) - dB							
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Sheet Steel	3	8	14	20	26	32	38	40

8.5.3 Acoustic Mitigation

The above noise data contains an amount of acoustic mitigation such as acoustic insulation on compressor piping. The data is based on vendor standard equipment (MR-PR Compressors, ACHE, GT Driver). Noise reduction for individual pieces of equipment (e.g., for GT Drivers, MR-PR Compressors, ACHE fans; and piping insulation) will be considered during FEED, where the engineering, operational and cost implications will be evaluated and considered together with other noise reduction measures, including measures at receptor locations or possible relocations.

9.0 PLANT NOISE EMISSIONS PREDICTIONS

9.1 On-Site Noise Predictions

Generally, the design of gas liquefaction sites can meet on-site noise levels of 85dB(A). There are some areas, such as compression areas and some utilities areas where noise levels of 85dB(A) cannot be met using practicable noise reduction measures. Noise levels in these areas typically will range between 95dB(A) and 105dB(A), particularly within buildings.

Within buildings (excluding machinery and other noisy areas), noise levels can be mitigated by using good building techniques and ensuring building services (such as HVAC) are suitably designed.

Operational upsets will cause noise levels up to 115dB(A) at accessible areas. All feasible design mitigations should be implemented to ensure that noise levels will not exceed 115dB(A) at accessible areas.

Construction noise could potentially also cause noise levels up to 115dB(A) at accessible locations and can also be impulsive in nature (piling). Noise monitoring is to be performed at all stages of construction operations to limit personnel exposure levels to acceptable levels.

9.2 Off-Site Noise Predictions

The noise model was performed to predict noise levels at indicative off-site locations (see Figure 1 below) to the east and west of the plant boundary. The noise model is based on previous gas liquefaction plant experience and considers that main equipment items (compressors, power generation and utilities) are contained within basic steel shelters.

Predicted noise levels at the closest off-site receptors is c. 58dB(A). The maximum predicted boundary noise level is c. 78dB(A) at locations adjacent to the LNG Trains.

It is also expected that operational upsets and construction phase sound power level emissions could be up to 20dB higher than from continuous operation.

The noise contours for the project are shown in Figure 1. Noise Predictions at specific locations are tabled below:

Receiver	dB(A)
S. E. House	57.2
W. House 1	57.8
W. House 2	55.5
W. House 3	55.6

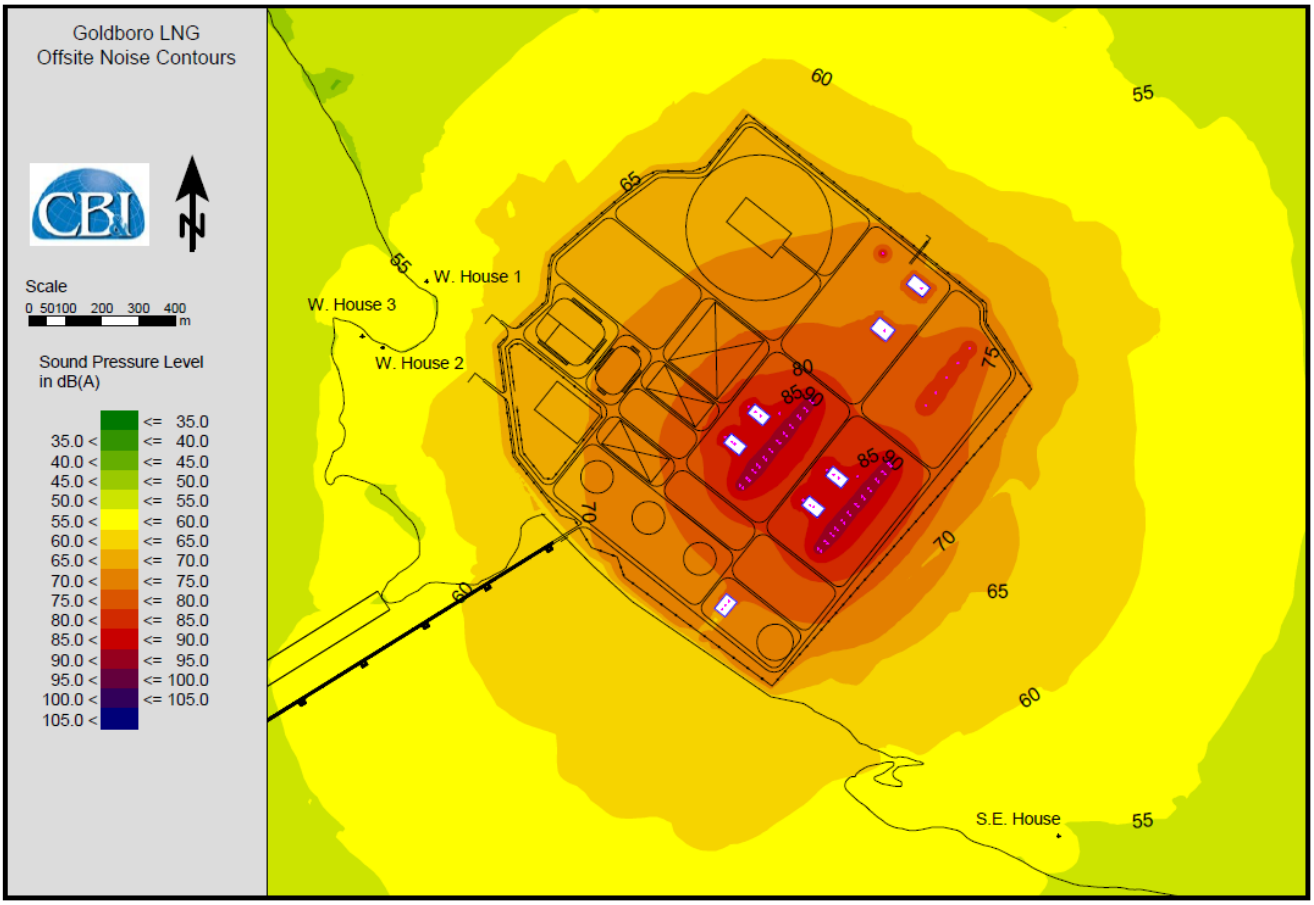

Figure 1 Noise Contours: Two LNG Trains

10.0 CONCLUSIONS

Based on the current simplified noise model there are 4 off-site receptors (three residential properties) which may exceed the 55dB(A) during normal operations of the LNG facility. The receptors are above the Nova Scotia guideline limits for night time. It is of note that these predictions are based on what is considered a conservative approach to the noise modelling. In particular, the preliminary noise model assumed a limited degree of on-site noise abatement, and no off-site mitigation.

During FEED, the finalised plot plan, finalized equipment specifications, and the new site topography, will be modelled to refine the predicted noise levels at the identified receptors. If required, noise abatement and mitigation measures will be implemented. This may include on-site as well as off-site measures.

All other receptors identified (local communities of Goldboro and Drum Head) will be within acceptable Provincial limits due to their relative distances to the proposed LNG Plant.

Cumulative effects with the SOEI plant, wind farm, traffic and other background noise sources has not yet been performed. The review of these cumulative effects shall be performed during the FEED Stage.

11.0 FURTHER WORK

This report contains a high level review of noise levels associated with gas liquefaction plants based on available documentation. The noise predictions made largely derive from previous experience with similar plants, environmental documentation produced for a different plant type and on publically available information.

In order to develop the noise model further and to finalize the site plot plan the following activities need to be undertaken during FEED:

- Further background noise level measurements,
- Review of proposed site contouring, contours adjacent to the site, existing vegetation and planned landscaping to refine model input parameters;
- Defined scope and extent of enclosures/winterisation, including building detailed design and scope and specifications of equipment contained within buildings.
- Plot layout review and adjustments for noise control purposes, including distances from major noise sources to the boundary, distances of major noise sources to off-site receptors, impact of low noise designs.
- Identification of up-to-date existing noise sources and incorporation with the model to ensure cumulative effects are included with the refined model predictions.
- Review extent of construction noise sources based on developed foundation designs and cut and fill requirements.
- Development of noise mitigation measures including a comprehensive Noise Management Plan for construction and operation phases.

APPENDIX 1 - LITERATURE SEARCH

What are the noise exposure limits in Canadian jurisdictions?

Jurisdiction (federal, provincial, territorial)	Continuous Noise		Impulse / Impact Noise	
	Maximum Permitted Exposure Level for 8 Hours: dB (A)	Exchange Rate dB(A) +	Maximum Peak Pressure Level dB(peak)	Maximum Number of Impacts
Canada (Federal)	87	3	-	-
British Columbia	85	3	140	-
Alberta	85	3	-	-
Saskatchewan	85	3	-	-
Manitoba	85	3	-	-
Ontario	85	3	-	-
Quebec	90	5	140	100
New Brunswick	85	3	140	-
Nova Scotia	85	3	140	100
Prince Edward Island	85	3	-	-
Newfoundland and Labrador (references ACGIH TLVs)	85	3	-	-
Northwest Territories	85	5	140	100
Nunavut	85	3 or 5*	140	-
Yukon Territories	85	3	140	90

+ When 3 dB exchange rate is used, generally there is no separate regulation for impulse/impact noise. The equivalent sound exposure level (L_{ex}) takes impulse noise into account in the same way as it does that for continuous or intermittent noise.

* In Nunavut, the General Safety Regulations reference a 5 dBA exchange rate. The Mining Health and Safety Regulations reference 3 dBA. Please contact Nunavut for further information.

Noise regulations in several jurisdictions treat impulse noise separately from continuous noise. A common approach is to limit the number of impulses at a given peak pressure over a workday. The exact figures vary slightly, but generally the regulations in which the exchange rate is 5 dB permit 10,000 impulses at a peak pressure level of 120 dB; 1,000 impulses at 130 dB; 100 impulses at 140 dB, and none above 140 dB.

Alternatively, using a 3 dB(A) exchange rate, impulse noise can be considered jointly with any continuous noise, in measuring the overall L_{eq} sound level.

Source: *http://www.ccohs.ca/oshanswers/phys_agents/exposure_can.html*
(Updated 4th Jul. 2011)

Table of Noise Criterion, ACGIH TLV and OSHA PEL

ACGIH Noise Level (dBA)	Exposure Duration (hours)	OSHA Noise Level (dBA)	Exposure Duration (hours)	ACGIH Noise Level (dBA)	Exposure Duration (hours)	OSHA Noise Level (dBA)	Exposure Duration (hours)
80	24.0000	80	32	117	0.00520	117	0.19
81	20.1600	81	27.9	118	0.00390	118	0.16
82	16.0000	82	24.3	119	0.00327	119	0.14
83	12.7000	83	21.1	120	0.00263	120	0.125
84	10.0800	84	18.4	121	0.00200	121	0.11
85	8.0000	85	16	122	0.00166	122	0.095
86	6.3500	86	13.9	123	0.00131	123	0.082
87	5.0400	87	12.1	124	0.00097	124	0.072
88	4.0000	88	10.6	125	0.00081	125	0.063
89	3.1700	89	9.2	126	0.00064	126	0.054
90	2.5200	90	8	127	0.00048	127	0.047
91	2.0000	91	7	128	0.00040	128	0.041
92	1.5900	92	6.1	129	0.00032	129	0.036
93	1.2600	93	5.3	130	0.00024	130	0.031
94	1.0000	94	4.6	131	0.00020		
95	0.7900	95	4	132	0.00016		
96	0.6300	96	3.5	133	0.00012		
97	0.5000	97	3	134	0.00010		
98	0.4000	98	2.6	135	0.00008		
99	0.3100	99	2.3	136	0.00006		
100	0.2500	100	2	137	0.00005		
101	0.2000	101	1.7	138	0.00004		
102	0.1600	102	1.5	139	0.00003		
103	0.1300	103	1.3	140	0.00000		
104	0.1000	104	1.1				
105	0.0800	105	1				
106	0.0600	106	0.87				
107	0.0500	107	0.76				
108	0.0400	108	0.66				
109	0.0300	109	0.57				
110	0.02521	110	0.5				
111	0.02044	111	0.44				
112	0.01567	112	0.38				
113	0.01304	113	0.33				
114	0.01043	114	0.29				
115	0.00781	115	0.25				
116	0.00650	116	0.22				

ACGIH uses a 3 dB doubling rate, whereas OSHA uses a 5 dB doubling rate for the allowed exposures. For instance, ACGIH TLV is 85 dB for 8 hours, and 88 dB for 4 hours. However, the OSHA PEL is 90 dB for 8 hours, and 95 dB for 4 hours. This discrepancy partially accounts for the differences in dose rates between the two criterion. The other discrepancy is the threshold at which instruments start to measure noise. OSHA's PEL threshold is 90 dBA, whereas ACGIH uses a threshold of 80 dB. The formula for noise is:

$$Dose = \frac{C1}{T1} + \frac{C2}{T2} + \cdots \frac{Cn}{Tn}$$

Where C is the number of minutes at a noise level, and T is the allowed number of minutes at that noise level using the criterion selected. The lower threshold allows more exposure to be measured.

Source : http://www.aiha.org/consumerinfo/Documents/Noise.pdf
(Note OSHA reference not applicable)

APPENDIX 2 - NOISE DEFINITIONS

The following definitions are explained in sufficient detail to define their meaning in relation to the requirements of this document.

Noise	Unwanted Sound
Sound Level	Is the A-weighted overall sound-pressure level.
Equivalent Sound Level (L_{AEQ})	Is a steady sound level which represents the same sound energy as a time varying sound level under consideration. (Applies for 3dB 'exchange rate') In this context it is used to provide a single sound level to represent the time varying sound level as an individual moves about the plant.
Sound Power Level	Is defined as:- $PWL=10xLog_{10}(W/ W_r)$ Where: PWL is the Sound Power Level in dB W is the Sound Power in watts W_r is the reference sound power of 10^{-12} watt.
Sound Pressure Level	Is defined as:- $SPL =10xLog_{10}(P/P_r)^2$ Where: SPL is the Sound Pressure Level in dB P is the sound pressure in N/m^2 P_r is the reference sound pressure of $2x10^{-5}$ N/m^2.
Directivity Index	Is the difference between the Sound Pressure Level in a particular direction compared with the average value for the source.
Attenuation	Is a reduction of Sound Level. This term is frequently used to describe the sound reduction property of walls or duct fittings. In this context it is frequently confused with Sound Absorption.
Absorption	Is the property of materials to convert incident sound energy to heat. Typical good sound absorbers are carpets, curtains, mineral wool and soft furnishings. Typical poor sound absorbers are concrete, ceramic tiles steel plate and hard plaster.
Reverberation	Is the persistence of sound in an enclosure caused by multiple reflections.
Reverberant Sound Level	Is the sound level which is due to reverberation within an enclosed space.
Direct Sound Level	Is the sound level from the sound that arrives from the source without undergoing any reflection.
Total Sound Level	Is the logarithmic addition of both Direct and Reverberant Sound Level.