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Noise Control and Vibration Insulation Study for an International Airport Building Generator Room

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Abstract

In mechanical volumes; there is a lot of equipment that make noise. These equipments cause direct and indirect transmission of noise to noise sensitive neighboring locations. For this reason, it is necessary to control the noise in the mechanical spaces, to ensure the control between the source and the source and the receiver, so that the indoor noise level, which should be applied to the noise sensitive neighboring spaces, must be ensured. In this scope, noise control, sound and vibration isolation performance analysis were performed an international airport building generator room. As a result of the analyzes made; BS-British Standards, DIN-Deutsches Institut für Normung-German Institute for Standardization and suggestions for the provision of acoustic comfort conditions.

Keywords: Acoustics, building acoustic, generator room, noise control, vibration.

1. Introduction

Today, mechanical volumes are generally composed of noisy equipments such as generators, heating and ventilation units, working in different frequencies. These working equipments results in direct or indirect transfer of the noise to adjacent noise sensitive rooms and volumes. As a result noise control actions must be executed first in the source than on the elements between source and receiver (walls, slab and ceiling) to provide a suitable volume sound level in these noise sensitive rooms.

In this work; International Airport Building Generator Room are analyzed in order to specify building elements, acoustic performances, with respect to noise control and vibration control, are conducted to specify,

- Airborne sound insulation and
- Impact (vibration) sound insulation

Analyses are conducted according to BS (British Standards), DIN (Deutsches Institut für Normung-German Institute for Standardization) and suggestions are made also considering acoustic literature knowledge.

2. Method

The method of this study is composed of;

• INSUL (V6.4) building acoustics simulation program is used to specify sound insulation performance of building components for noise control generators,

• Crosscheck is made by mathematical methods to determine projected noise levels in sound sensitive receiver rooms.

Sound power level (dBA) of the equipments in the generator room is obtained from the manufacturer. Generator rooms are located on the Level 01 Arrival Floor at the right and left end of the building. There is no other level below, these rooms. Generator rooms are approximately two floors tall (8.10 m) and on Level 03 Departure Floor, Leasable Area is above these rooms. The study was conducted with these data and limitations in mind.

3. Analysis and Evaluation of Building Components for Noise Control

Sound insulation performance is conducted for building elements between Generator rooms, Leasable Area above and surrounding rooms in an International airport building. Source room and receiver room positions are stated below both on plan and cross-section at Figure 1 and Figure 2. BS 8233:2014 and DIN 4109 specifications sound performance index are used to set building acoustic analysis values.

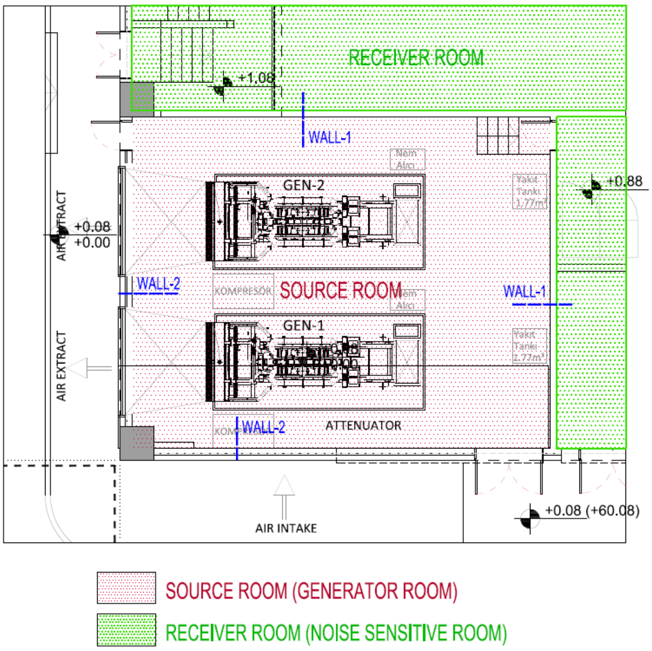


Figure 1. Source and receiver room locations-plan

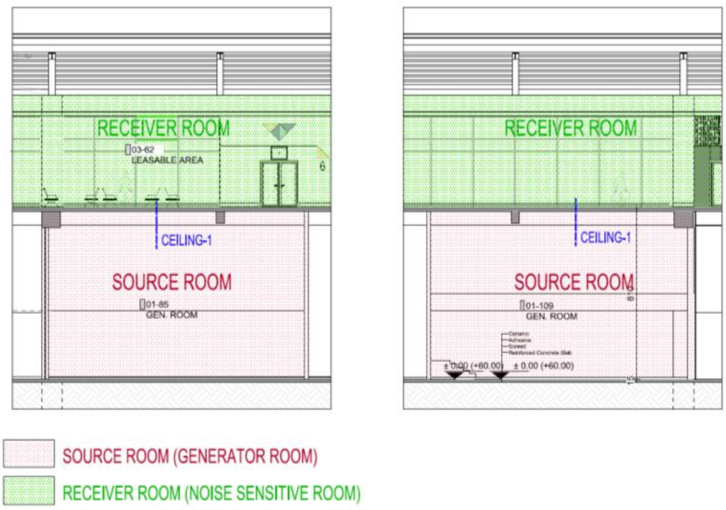


Figure 2. Source and receiver room locations-section

Below parameters are used in the sound insulation performance analysis and evaluation of the generator room internal building components:

- Rw : Weighted sound reduction index, in dB *(airborne sound)*
- DnT : Standardized Level Difference , in dB *(airborne sound)*

Table 1 and Table 2 shows required airborne and impact sound insulations of building elements according to BS 8233:2014 and DIN 4109.

Table 1. Required airborne and impact sound insulations of building elements between very noisy rooms and noise sensitive rooms [DIN 4109]

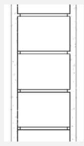
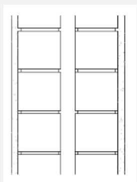
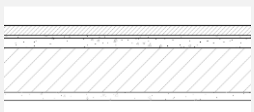
NOISE SOURCE	Building elements considered	Weighted sound reduction index, Rw, in dB, for		Weighted normalized impact sound pressure level, Lnw, in dB
		LAF from 75 to 80 dB(A)	LAF from 81 to 85 dB(A)	
Rooms with very noisy building service sor service equipment	Floors*, walls	57	62	-
	Floors	-		43
*Floors above rooms considered.				

Table 2. Example sound insulation matrix (dB, DnT,w) [BS 8233]

Privacy requirement	Activity noise of source room	Noise sensitivity of receiving rooms		
		Low sensitivity	Medium sensitivity	Sensitive
Confidential	Very high	47	52	57
	High	47	47	52
	Typical	47	47	47
	Low	42	42	47
Moderate	Very high	47	52	57
	High	37	42	47
	Typical	37	37	42
	Low	No rating	No rating	37
Not private	Very high	47	52	57
	High	37	42	47
	Typical	No rating	37	42
	Low	No rating	No rating	37

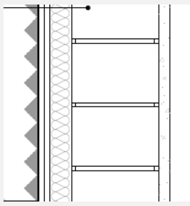
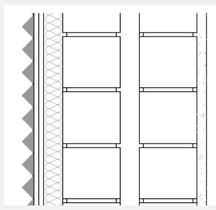
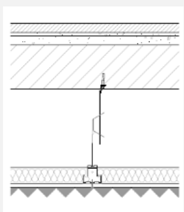
Existing design is evaluated to state current conditions within the scope of sound insulation on Table 3. For inappropriate conditions new designs are evaluated and suggestions are made on Table 4 and 5.

Table 3. Analysis of sound insulation performances of current design building components

WALL-1 (Wall separating Generator Chamber and other technical chambers)			
CURRENT DESIGN d=20 cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Paint • Plaster 2,5 cm • Brick wall 20 cm • Plaster 2,5 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 54 (-1; -5) DnT,w (C; C_{tr}) 56 (-1; -5) NOT SUITABLE
WALL-2 (Generator Room exterior wall)			
CURRENT DESING d=35 cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Paint • Plaster 2,5 cm • Brick wall 15 cm • Air gap 5 cm • Brick wall 15 cm • Plaster 3 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 59 (-2; -7) DnT,w (C; C_{tr}) 61 (-2; -7) NOT SUITABLE
CEILING-1 (Ceiling / flooring separating the Generator Chamber and Leasable Area)			
CURRENT DESIGN d=14cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Granite ceramic floor covering • Screed • Reinforced concrete slab 14 cm • Plaster 2,5 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 55 (-1; -4) DnT,w (C; C_{tr}) 57 (-1; -4) NOT SUITABLE
* The above values; since it is not suitable according to BS and DIN standards, it is deemed appropriate to develop suggestions.			

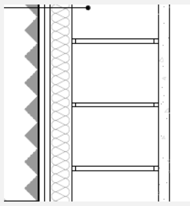
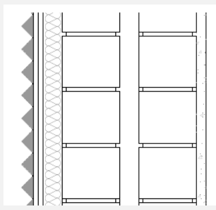
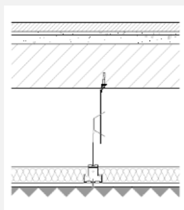
Results show that current design on both walls and ceiling are not enough to meet requirements. Using simulation suggestions are made and Suggestion-1 is shown in Table 4 and Suggestion-2 in shown in Table 5. On Figure 3 show Wall-slab, Wall-Ceiling details are shown.

Table 4. Analysis of the sound insulation performance of building components for suggestion-1

Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
WALL-1 (Wall separating Generator Chamber and other technical chambers)			
SUGGESTION-1 d=30 cm			
• Polyethylene foam ≥27 mm (≥70 kg/m^3) • EPDM rubber sound isolation barrier ≥2.5 mm (≥ 5 kg/m^2) • Gypsum board panel 2x12,5 mm • Rockwool 50 mm (50 kg/m^3) • Brick wall 20 cm • Plaster 2,5 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 70 (-3; -9) DnT,w (C; C_{tr}) 72 (-3; -9) SUITABLE
WALL-2 (Generator room exterior wall)			
SUGGESTION-1 d= 45 cm			
• Polyethylene foam ≥ 27 mm (≥70 kg/m^3) • EPDM rubber sound isolation barrier ≥2.5 mm (≥ 5 kg/m^2) • Gypsum board panel 2x12,5 mm • Rockwool 50 mm (50 kg/m^3) • Brick wall 15 cm • Air gap 5 cm • Brick wall 15 cm • Plaster 3 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 74 (-4; -14) DnT,w (C; C_{tr}) 76 (-4; -14) SUITABLE
CEILING-1 (Ceiling / flooring separating the Generator Chamber and Leasable Area)			
SUGGESTION-1 d=43 cm			
• Granite ceramic floor covering • Screed • Reinforced concrete slab 14 cm • Air gap 25 cm • Rockwool 50 mm (50 kg/m^3) • Gypsum board suspended ceiling 12,5 mm • EPDM rubber sound isolation barrier ≥2.5 mm (≥ 5 kg/m^2) • Polyethylene foam ≥27 mm (≥70 kg/m^3)		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 72 (-2; -6) DnT,w (C; C_{tr}) 74 (-2; -6) SUITABLE

* Least strong wall is detailed within the scope of acoustic and rest of te walls are assumed accordingly.
*Although above values are satisfying according to acoustic concerns, materials can be used if and only if materials are inflammable.

Table 5. Analysis of sound insulation performances of building components for suggestion-2

WALL-1 (Wall separating Generator Chamber and other technical chambers)			
SUGGESTION-2 d=30 cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Melamine foam ≥30 mm (≥10 kg/m³) • Polymer based sound isolation barrier ≥2.5 mm (≥ 5 kg/m²) • Gypsum board panel 2x12,5mm • Rockwool 50 mm (50 kg/m³) • Brick wall 20 cm • Plaster 2,5 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 70(-3; -9) DnT,w (C; C_{tr}) 72 (-3; -9) SUITABLE
WALL-2 (Generator room exterior wall)			
SUGGESTION-2 d= 45 cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Melamine foam ≥30 mm (≥10 kg/m³) • Polymer based sound isolation barrier ≥2.5 mm (≥ 5 kg/m²) • Gypsum board panel 2x12,5 mm • Rockwool 50 mm (50 kg/m³) • Brick wall 15 cm • Air gap 5 cm • Brick wall 15 cm • Plaster 3 cm • Paint		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 74 (-4; -14) DnT,w (C; C_{tr}) 76 (-4; -14) SUITABLE
CEILING-1 (Ceiling / flooring separating the Generator Chamber and Leasable Area)			
SUGGESTION-2 d=43 cm			
Material Information	Structure Composition Detail	Optimum Value	Analysis Result and Evaluation
• Granite ceramic floor covering • Screed • Reinforced concrete slab 14 cm • Air gap 25 cm • Rockwool 50 mm (50 kg/m³) • Gypsum board suspended ceiling 12,5 mm • Polymer based sound isolation barrier ≥2.5 mm (≥ 5 kg/m²) • Melamine foam ≥30 mm (≥10 kg/m³)		Rw ≥ 62 dB [DIN] DnT,w ≥ 57 dB [BS]	Rw (C; C_{tr}) 72 (-2; -6) DnT,w (C; C_{tr}) 74 (-2; -6) SUITABLE

* Least strong wall is detailed within the scope of acoustic and rest of te walls are assumed accordingly.
* Above values are evaluated and suggested as proper/suitable design, considering noise control, sound insulation and fire performances.

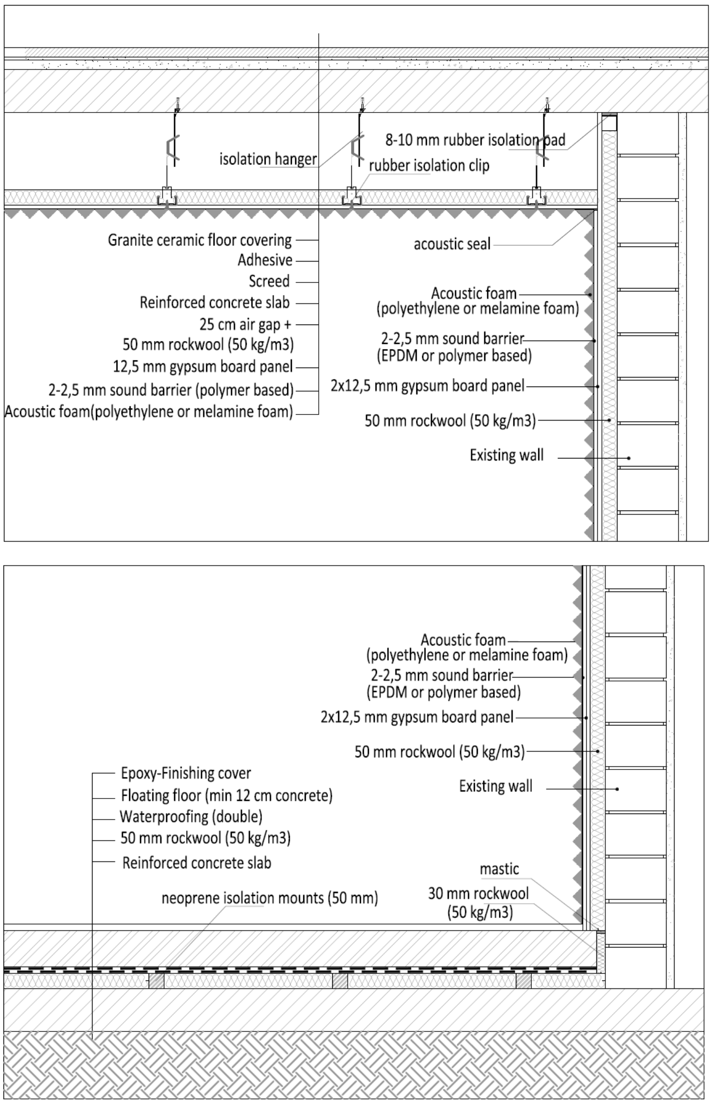


Figure 3. Floor-wall, wall-ceiling joints details

Table 6. Typical ambient noise levels in non-domestic buildings [BS 8233]

Activity	Location	Design range dB LAeq, T
Speech or telephone communications service equipment	Department store Cafeteria, canteen, kitchen	50 – 55
	Concourse Corridor, circulation space	45 – 55

Table 6 shows BS 8233:2014 non-domestic buildings typical ambient noise levels. Suggestions stated in Table 4 and 5 are checked with mathematical methods to state neighbor rooms sound levels and evaluations are shown in Table 7.

Table 7. As a result of the proposed suggestions, evaluation with the noise levels predicted in the receiving rooms

Source Room Noise Level (SPLA-dBA)	Sound Insulation Performance of Building Component (Analysis)	Proposed Limits Leq (dBA)	Noise Level Predicted in Receiver Room (SPLA-dBA)	Assessment
115 ***Generator Room (Double Generator)***	**DnT,w (C; C_{tr}) 72 (-3; -9) Rw (C; C_{tr}) 70 (-3; -9)** ***Wall***	**50** ***Leasable Area***	**46,71** ***Leasable Area***	**SUITABLE**
115 ***Generator Room (Double Generator)***	**DnT,w (C; C_{tr}) 74 (-2; -6) Rw (C; C_{tr}) 72 (-2; -6)** ***Floor***	**50** ***Leasable Area***	**41,62** ***Leasable Area***	**SUITABLE**

- ***Source Room noise levels were calculated by taking into account the highest sound pressure levels of the equipment in the rooms.***

4. Analysis and Evaluation for Vibration Insulation

Direct transfer of the vibration produced by the mechanical equipments for building main structure, floating slab or pedestal application under mechanical equipments is proposed. Direct transfer of the vibration to building main structure will result transfer of noise to adjacent and even all of the building itself. In this application, the insulation pads to be used must perform above this static deflection value. Also, additional vibration insulation springs must be placed under the equipments above floating concrete slab. There must be non-slip neoprene acoustic pads must be placed. Detail is shown on Figure 4. Minimum static deflection values for the chosen equipments are given in Table 8. Figure 4 shows vibration insulation spring detail, Figure 5 and Figure 6 shows suggested floating slab details.

Table 8. The minimum value of static deflection calculated according to the devices used

Name of Equipment	Location	Period (Rpm)	Static Deflection Value (mm)
Generator Group	Generator Room	1500	15,00

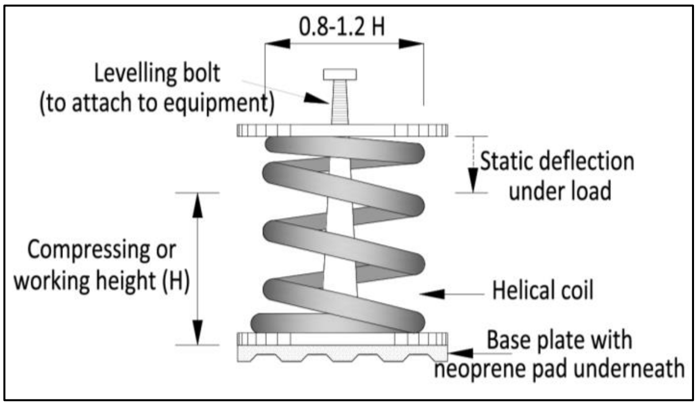


Figure 4. Vibration isolator spring detail

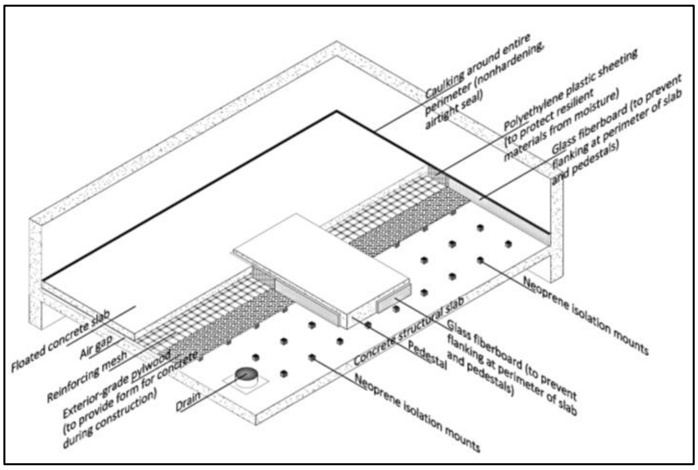


Figure 5. Floating floor/slab detail

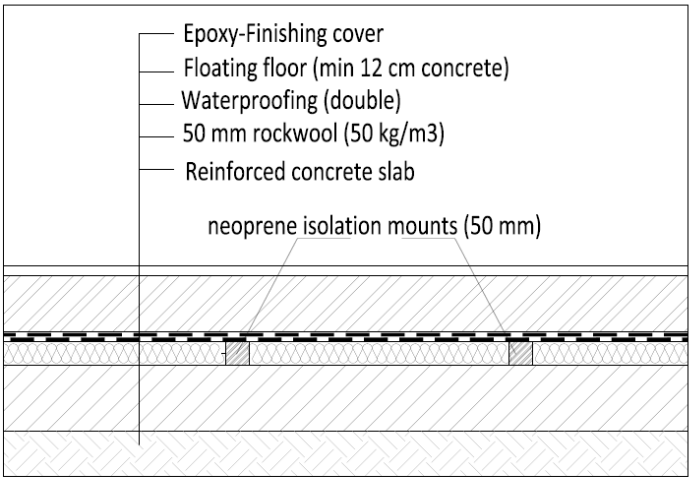


Figure 6. Suggested floating floor/slab detail

5. Conclusion

In this study, required acoustical parameters are set according to BS (British Standards), DIN (Deutsches Institut für Normung- German Institute for Standardization) and detailed work is done to specify required design details to provide these conditions for an international airport building generator room.
According to "Avoid noise at the source" principle; additional exhaust **mufflers shall be added** to the equipments to decrease initial noise levels.
Study for noise control and vibration insulation for this Generator Room is summarized below;

- **Surrounding walls of generator room**; Inner Wall, Wall-1: 20 cm brick, Outer Wall, Wall-2 15 cm brick+ 5 cm free air space and 15 cm brick Wall does not meet the required acoustic performance (Table 3). As a result two different suggestions are made accordingly;
  - **Suggestion – 1:** On top of existing Wall 5 cm rock wool (50 kg/m^3) + 2 layer gypsum board (12,5 mm each) + 2.5 mm EPDM rubber sound isolation barrier + 27 mm or more acoustic foam (polyethylene foam) (Table 4, Annex 1d). Alternatively acoustic foam with a rubber sound isolation barrier in it can be used. **However, this combination is only valid where layer materials are fire resistive and non-flammable.**
  - **Suggestion-2:** On top of existing Wall 5 cm rock wool (50 kg/m^3)+2 layer gypsum board (12,5 mm each) + 2,5 mm polymer based sound isolation barrier + 30 mm or more melamine foam (Table 5, Annex 1d). Alternatively melamine foam with polymer sound isolation barrier in it can be used. Since melamine foam and sound isolation barrier is non-flammable, does not produce poisonous gases and non-smoke produce this application is applicable considering fire and acoustic. This material is produced grey and white colors. Material can be coloured if Engineer/Employer wants black colour. Most important part of the colouring is that existing fire and acoustic properties of the material must not be harmed due to paint.
- **Above slab between Generator room and Leasable Areas,** Ceiling 1; Existing 14cm slab and plaster work does not provide enough sound insulation. Therefore two different suggestions are made;
  - **Suggestion – 1:** Gypsum board suspended ceiling with 25 cm free air space and 1 layer of gypsum board (12,5 mm) + 5 cm rock wool (50 kg/m^3) above gypsum board + 2,5 mm EPDM rubber sound barrier below gypsum board + minimum 27 mm thick acoustic foam (polyethylene foam) (Figure 4, Annex 1f). Alternatively foam with barrier composed material is also valid. **However this combination is only valid where layer materials are fire resistive and non-flammable.**
  - **Suggestion – 2:** Gypsum board suspended ceiling with 25 cm free air space and 1 layer of gypsum board (12,5 mm) + 5 cm rockwool (50 kg/m^3) above gypsum board + 2,5 mm polymer based sound barrier below gypsum board + minimum 30 mm thick melamine foam (Figure 4, Annex 1f). Alternatively foam with barrier composed material is also valid. **Since the material has better performance among fire as being non-flammable, non-poisonous gas producing and non-smoke producing, usage of the material is found as applicable.** This material is produced grey and white colors. Material can be coloured if Engineer/Employer wants black colour. **Most important part of the colouring is that existing fire and acoustic properties of the material must not be harmed due to paint.**
- **Considering vibration insulation**, floating slab below the equipments and springs above the slab and under the equipments are suggested. In this application; the insulation pads and springs to be used must perform above this static deflection value. There must be non-slip neoprene acoustic pads under springs (Figure 4 and Figure 5)

References

[1] Marshall Day Acoustics, (2011). "INSUL Sound Insulation Prediction, V 6.4.12".

[2] DIN 4109, (1989)"Sound insulation in buildings", Germany.

[3] BS 8233:2014, (2014), "Guidance on Sound Insulation and Noise Reduction for Buildings", BSI Standards Publication.

[4] Die neue DIN 4109 Auf der Spur von Innovationen, (2017), Wolfgang Sorge Ingenieurbüro für Bauphysık, Beraten Planen Prüfen.

[5] Egan, M. D., (2007), "Architectural Acoustics, 1st edition", J. Ross Publishing Inc., Fort Lauderdale.

[6] Mehta, M., Johnson, J., Rocafort, J., (1999). "Architectural Acoustics Principles and Design" Merrill Prentice Hall, 301-306.

[7] Demirel, F., (2017). "Architectural Acoustics Unpublished Lecture Notes", Gazi University Faculty of Architecture, Ankara.

ANNEXES

ANNEX-2: Data associated with equipment

Annex-2a: Sound pressure levels of equipment (Position 7)

Name of Equipment	Frequency (Hz)							Sound Pressure Level (dBA)
	125	250	500	1000	2000	4000	8000	
Generator-1	112	110	107	105	105	102	102	107
Generator-2	112	110	107	105	105	102	102	107

Annex-2b: Properties of equipment

Device Name	Device code	Number of device	Device operation weight (kg)	Device dimensions (Length x Width x Height) m
GENERATOR SET	1600-2183 kWm (Gross)	2	7783	2185x4542x3175

Annex-2c: Static deflection graph