Good Practices on the Control of Noise from Electrical & Mechanical Systems

環境保護署
Environmental Protection Department

控制機電系統噪音的優良手法

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1. Introduction

Under the Noise Control Ordinance, noise generated from activities carried out in industrial or commercial premises should comply with the noise standards as stipulated in the relevant Technical Memorandum. It is generally recognized that operation of electrical & mechanical systems, such as ventilation systems, pumping systems, lift systems and emergency generator sets, is one of these noisy activities. This booklet highlights the importance of planning against noise problems. It gives a brief description of potential noise problems associated with electrical & mechanical systems and provides guidelines on practical noise control measures that are applicable for new designs and for retrofitting existing designs.

The reader should note that compliance with the recommendations of this booklet does not necessarily mean compliance with the legislative requirements. Besides, the recommendations made in this booklet are not exhaustive. Alternative solutions to achieve the same results may exist. The reader is therefore advised to consult independent expert for ensuring the use of proper and cost-effective noise control measures.

This booklet is designed mainly for assisting restaurant operators, building operators, building management, incorporated owners, and contractors to better understand noise control knowledge in relation to the operation of their mechanical & electrical systems and hence adopting the most appropriate mitigation measures where necessary. Architects, building services engineers or other relevant professional parties may also use it as a checklist to ensure that proper measures will be taken to avoid noise problems in designing electrical & mechanical systems and locating equipment. The main contents are written in plain language and illustrated by schematic diagrams for easy understanding by a layman. The focus is on practicable measures. More technical information can be found in appendices.

1. 導言

根據噪音管制條例，工業或商業活動所產生的噪音應符合有關技術備忘錄內所規定的噪音標準。而機電系統的操作，例如通風系統、抽水系統、升降機系統及緊急發電機，是其中一種常見的嘈吵活動。本小冊子首先強調以規劃防止噪音問題的重要性，再簡短描述機電系統潛在的噪音問題，同時提供可應用於新設計系統或翻新系統上的實用噪音控制措施。

讀者應留意符合本小冊子的建議不代表符合法定的要求。此外，除本小冊子所建議的方法外，可能還有其他解決方法。因此，讀者應尋求專業人士意見，以確保採用適當及高成本效益的噪音控制措施。

本小冊子是專為協助食肆營運者、大廈營運者、業主立案法團、大廈管理人員、及機電系統承建商更了解噪音控制知識而編寫。建築師、屋宇設備工程師及其他有關專業人員也可利用本小冊子作為核對清單，以確保在設計機電系統或安置機電設備時會採用適當措施避免噪音問題。本小冊子主要內容均以簡易文字附以圖解編寫，務求一般讀者容易明白，而焦點集中於實際可行的措施上。更多的技術性資料則可在附錄中找到。

2. Quick Reference Guide

The following quick reference guide allows the reader to go directly to the relevant section or appendix concerning a particular problem.

Table 1 : Quick Reference Guide for Ventilation Systems

Source of Noise Problem	Remedies	Relevant Section	Relevant Appendix
Chillers	- Barrier	5.1.1	Appendix VI
	- Partial enclosure	5.1.1	Appendix V
	- Complete enclosure	5.1.1	Appendix IV
	- Silencer	5.1.1	Appendix IX
	- Floating floor	5.1.1	Appendix X
	- Vibration isolator	5.1.1	Appendix VIII
Water Cooling Towers	- Barrier	5.1.2	Appendix VI
	- Partial enclosure	5.1.2	Appendix V
	- Complete enclosure	5.1.2	Appendix IV
	- Silencer	5.1.2	Appendix IX
	- Acoustic mat	5.1.2	--
	- Lined vent cowl	5.1.2	--
	- Vibration isolator	5.1.2	Appendix VIII
Fans	- Silencer	5.1.3	Appendix IX
	- Complete enclosure	5.1.3	Appendix IV
	- Fan speed reduction	5.1.3	--
	- Diverting	5.1.3	--
	- Inertia block	5.1.3	Appendix VII
	- Vibration isolator	5.1.3	Appendix VIII
	- Flexible connector	5.1.3	--
Ducts	- Stiffening	5.1.4	--
	- Damping material	5.1.4	--
	- Composite lagging	5.1.4	--

2. 簡便指南

下列簡便指南方便讀者直接翻閱相關噪音問題的段節或附錄。

表1： 通風系統的簡便指南

噪音問題的來源	矯正方法	有關的段節	有關的附錄
冷卻器	- 隔音屏障	5.1.1	附錄六
	- 局部隔音罩	5.1.1	附錄五
	- 完全隔音罩	5.1.1	附錄四
	- 消聲器	5.1.1	附錄九
	- 浮動地台	5.1.1	附錄十
	- 避震器	5.1.1	附錄八
冷卻水塔	- 隔音屏障	5.1.2	附錄六
	- 局部隔音罩	5.1.2	附錄五
	- 完全隔音罩	5.1.2	附錄四
	- 消聲器	5.1.2	附錄九
	- 吸音蓆	5.1.2	--
	- 通風罩	5.1.2	--
	- 避震器	5.1.2	附錄八
抽氣扇	- 消聲器	5.1.3	附錄九
	- 完全隔音罩	5.1.3	附錄四
	- 減低抽氣機機轉速	5.1.3	--
	- 轉向	5.1.3	--
	- 浮動混凝土底座	5.1.3	附錄七
	- 避震器	5.1.3	附錄八
	- 彈性接口	5.1.3	--
管道	- 強代震動管道表層	5.1.4	--
	- 具阻尼減震物料	5.1.4	--
	- 合成橫擋板	5.1.4	--

Table 2 : Quick Reference Guide for Pumping Systems

Source of Noise Problem	Remedies	Relevant Section	Relevant Appendix
Pipes	- Large radius bend pipe	5.2.1	--
	- Composite lagging	5.2.1	--
	- Low water flow velocities	5.2.1	--
	- Rigid mountings around the bend	5.2.1	--
	- Vibration isolator	5.2.1	Appendix VIII
	- Compressible material	5.2.1	--
	- Pressure reducing valve	5.2.1	--
Pumpsets	- Barrier	5.2.2	Appendix VI
	- Partial enclosure	5.2.2	Appendix V
	- Complete enclosure	5.2.2	Appendix IV
	- Replacement of bearing	5.2.2	--
	- Inertia block	5.2.2	Appendix VII
	- Vibration isolator	5.2.2	Appendix VIII
	- Flexible connector	5.2.2	--

Table 3 : Quick Reference Guide for Lift Systems

Source of Noise Problem	Remedies	Relevant Section	Relevant Appendix
Traction Machines	- Plantroom	5.3.1	Appendix IV
	- Inertia block	5.3.1	Appendix VII
	- Vibration isolator	5.3.1	Appendix VIII
Guide Rails	- Vibration pads	5.3.2	Appendix VIII
Hydraulic Lifts	- Complete enclosure	5.3.3	Appendix IV
	- Vibration isolator	5.3.3	Appendix VIII

Table 4 : Quick Reference Guide for Emergency Generator Sets

Source of Noise Problem	Remedies	Relevant Section	Relevant Appendix
Emergency Generator Sets	- Plantroom	5.4.1	Appendix IV
	- Vibration isolator	5.4.1	Appendix VIII
	- Flexible connector	5.4.1	--

表2： 抽水系統的簡便指南

噪音問題的來源	矯正方法	有關的段節	有關的附錄
喉管	- 較大半徑彎位喉管	5.2.1	--
	- 合成橫擋板	5.2.1	--
	- 低水流速度	5.2.1	--
	- 固定彎位的堅硬座架	5.2.1	--
	- 避震器	5.2.1	附錄八
	- 可壓縮物料	5.2.1	--
	- 減壓閥	5.2.1	--
水泵組	- 隔音屏障	5.2.2	附錄六
	- 局部隔音罩	5.2.2	附錄五
	- 完全隔音罩	5.2.2	附錄四
	- 更換損壞軸承	5.2.2	--
	- 浮動混凝土底座	5.2.2	附錄七
	- 避震器	5.2.2	附錄八
	- 彈性接口	5.2.2	--

表3： 升降機系統的簡便指南

噪音問題的來源	矯正方法	有關的段節	有關的附錄
曳引機械	- 機房	5.3.1	附錄四
	- 浮動混凝土底座	5.3.1	附錄七
	- 避震器	5.3.1	附錄八
導軌	- 避震軟墊	5.3.2	附錄八
油壓升降機	- 完全隔音罩	5.3.3	附錄四
	- 避震器	5.3.3	附錄八

表4： 緊急發電機的簡便指南

噪音問題的來源	矯正方法	有關的段節	有關的附錄
緊急發電機	- 機房	5.4.1	附錄四
	- 避震器	5.4.1	附錄八
	- 彈性接口	5.4.1	--

3. Statutory Control over Noise

Noise generated from electrical & mechanical systems in commercial and industrial premises is controlled under the Noise Control Ordinance (Cap. 400) by means of a Noise Abatement Notice mechanism. "Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites" (TM), as issued under Section 10 of the Noise Control Ordinance, sets out objective noise control criteria in the form of Acceptable Noise Levels (ANL). Noise Abatement Notices may be served on owners or operators of the systems if the emitted noise measured at a Noise Sensitive Receiver (NSR), such as a residential building or a school, does not comply with the noise control criteria.

A brief extract of the technical noise assessment and criteria from the TM is included in Appendix I for easy reference.

3. 法定噪音管制

機電系統所發出的噪音是受「噪音管制條例」(第 400 章) 所管制。根據「噪音管制條例」第 10 條發出的「管制非住用處所、非公眾地方或非建築地盤噪音技術備忘錄」訂明了評估除住用處所、公眾地方或建築地盤以外地方發出的噪音所用的準則及列出了「可接受的噪音聲級」。假如機電系統所發出的噪音在一特定「噪音感應強的地方」（例如：住宅大廈或學校）並不符合以上技術備忘錄內所載的「可接受的噪音聲級」，有關當局會根據該技術備忘錄向該系統之擁有者或操作者發出「消減噪音通知書」，藉此而實施管制。

附錄一簡單引述了「管制非住用處所、非公眾地方或非建築地盤噪音技術備忘錄」於「噪音感應強的地方」的「可接受的噪音聲級」、噪音評估位置及指引，方便讀者參考。

4. General Principles and Techniques of Noise Control

4.1. Planning against Noise Problems

4.1.1. Positioning of Equipment

The installation position of equipment is of critical importance in determining the level of noise to be transmitted to the nearby noise sensitive receivers (e.g. residential buildings or schools).

Where practicable, the equipment should be placed in a plant room with thick walls or at a location with much greater distance from the receiver or behind some large enough obstruction (e.g. a building or a barrier) such that the line of sight between the receiver and the equipment is blocked.

Design of residential buildings should avoid locating area of noise sensitive uses (e.g. bedrooms) next to noise sources (e.g. machine rooms, lift shafts, etc.). Instead, other areas of less noise sensitive use (e.g. corridors, kitchens, bathrooms, etc.) may be assigned to separate area of noise sensitive uses from noise sources. This can avoid some future noise problems and possible costs for any subsequent noise control measures.

If noisy equipment has to be placed near a receiver due to spatial or other constraints, appropriate noise control measures should be considered.

4.1.2. Selection of Quiet Equipment

Though equipment may generally be more expensive. It is however, more economical in the long run to buy quieter equipment (e.g. silent type chillers, water cooling towers, or pumps) than to carry out abatement work for mitigating excessive noise generated from noisy equipment. Most equipment has a range of readily available noise control devices that are able to curb down the noise. It is advisable that noise levels specification is included when ordering new equipment. This allows the equipment suppliers to select appropriate equipment and optional noise control devices to suit the acoustic requirements.

4. 噪音控制的通用原理及技巧

4.1. 防止噪音問題的規劃

4.1.1. 設備的安置

設備的安裝位置是決定在「噪音感應強的地方」（例如：住宅大廈或學校）的噪音聲級的重要因素。

在情況許可下，設備應放置在厚壁的機房內或遠離任何「噪音感應強的地方」或置於體積大的障礙物後（例如：建築物或隔音屏障），務求設備與「噪音感應強的地方」之間的視線受阻。

住宅大廈的設計上應避免設置「噪音感應強的地方」（例如：睡房）於噪音源（例如：機房、升降機井道等）附近，而以其他用途的空間（例如：走廊通道、廚房、浴室等）分隔，可避免一些將來可能會出現的噪音問題，也能減低額外噪音控制措施的成本。

假如因為空間或其他因素下，嘈吵的設備必需置於「噪音感應強的地方」附近，則應採用足夠的噪音控制措施。

4.1.2. 選擇寧靜的設備

一般而言，寧靜的設備普遍比較昂貴。但是長遠來說，購買寧靜設備較購買廉價設備後再作消減噪音的修正更為經濟（例如：超靜冷卻器、冷卻水塔或水泵）。大多數設備已有一系列噪音控制裝備作為處理其本身噪音之用。當購買新設備時，宜說明所需噪音聲級規格，這樣，設備供應商就能挑選合適的設備及噪音控制裝備以符合所需之噪音聲級規格。

4.1.3. Proper Implementation of Noise Mitigation Measures

If noise mitigation measures are required, it is important that they are implemented properly. For example, gaps at noise barriers and enclosures should be sealed up to prevent noise leakage, vibration isolators should be allowed to perform at their designed deflection ranges without being locked up or being short-circuited by other transmission paths. Examples are shown in Section 5.5 for reference.

4.1.4. Scheduled Maintenance

In order to prevent increasing noise produced by existing equipment, it is necessary to put in place a regularly scheduled equipment maintenance programme so that equipment is properly operated and serviced in order to maintain controlled level of noise and vibration. Maintenance may include lubricating moving parts, tightening loosen parts, replacing worn-out components or inspecting equipment alignment, etc. Vibration measurements at various frequencies may help to detect causes of excessive vibration or noise of a machine. A guide to vibration identification is given in Appendix XIII.

4.1.3. 噪音緩解措施的正確安裝

如機電設備需配備噪音緩解措施，噪音緩解措施的正確安裝是尤其重要。例如：安裝隔音屏障時需留意有否可滲漏噪音的間隙及接口，如有則應妥善的封上，以避免因滲漏噪音而大大減低隔音屏障的隔音效果；安裝避震器時需留意避震器不應被鎖上或被其他傳遞路徑繞過，否則會大大影響其隔震功能。段節 5.5 列出了一些示例以供參考。

4.1.4. 定期保養

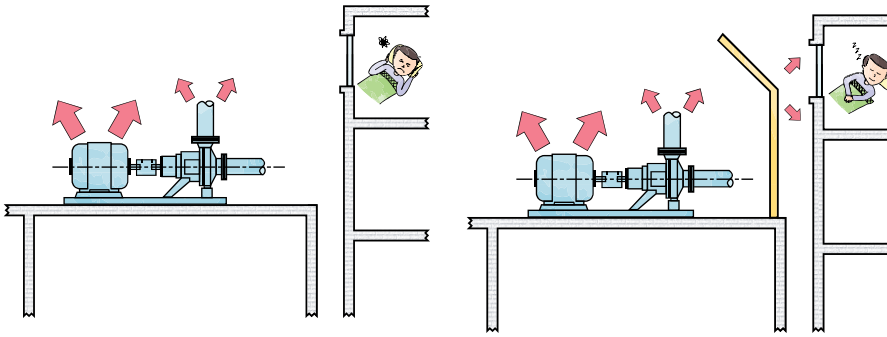
為了防止現有設備的噪音加增，用戶應制定定期保養計劃以確保設備正運作及其發出的噪音或震動受到控制。保養項目可包括添加潤滑油於活動部份、扭緊鬆脫的零件、更換損壞的組件及調準設備組件等。量度設備不同頻率的震動有助明瞭過量震動或噪音的成因。有關辨別震動來源的指引可見附錄十三。

4.2. Tackling Existing Problems against Noise Exceedance

4.2.1. Air-borne Noise Control

Noise generated from electrical & mechanical equipment may cause disturbance to nearby residents.

The noise may be mitigated by blocking the line of sight between the equipment and the receiver. Depending on the required level of noise reduction, noise barriers, partial enclosure and complete enclosure may be considered (see Figure 1 and Appendices IV to VI).



Air-borne noise without control measures

Air-borne noise control by barriers or partial enclosures

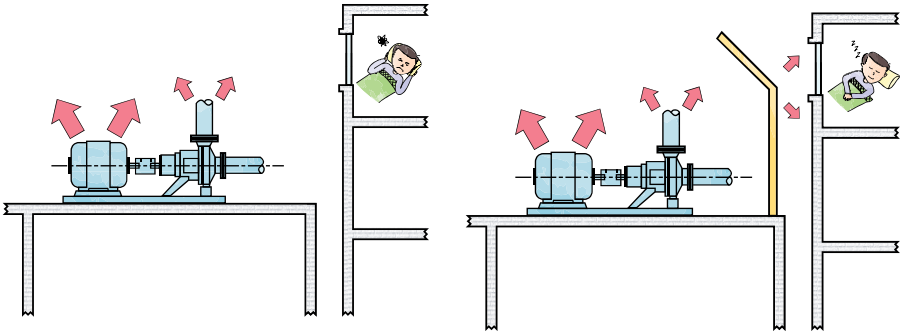
Figure 1 : Air-borne Noise Control by Barriers and Enclosures

4.2. 現有噪音過量問題的緩解

4.2.1. 經空氣傳遞的噪音的控制

機電設備的噪音可對其附近的居民造成噪音騷擾。

經空氣傳遞的噪音可以通過圍封噪音以達到隔音的效果。緩解措施一般包括隔音屏障、局部隔音罩及完全隔音罩，視乎現場環境及所需的隔音效果而選擇（參考圖 1、附錄四至附錄六）。



經空氣傳遞的噪音　　以隔音屏障或隔音罩控制經空氣傳遞的噪音

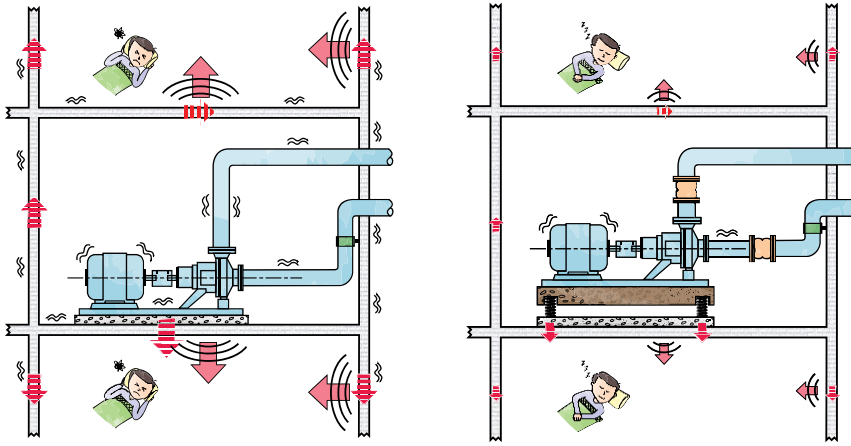
圖1：　以隔音屏障或隔音罩控制經空氣傳遞的噪音

4.2.2. Structure-borne Noise Control

Vibration from electrical & mechanical equipment may be transmitted through building structure at points where the chiller is connected to the structure. The situation could be particularly worse when it is rigidly fixed to the structure without proper isolation. The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

The vibration may be isolated from the building structure controlled by using vibration isolators (see Figure 2 and Appendix VIII).

In addition, inertia blocks may also be provided between the vibration isolators and some mechanical equipment such as fans and pumps to add rigidity and stability of the system (see Figure 2 and Appendix VII).



Structure-borne noise without control measures

Structure-borne noise control by vibration isolators

Figure 2 : Structure-borne Noise Control by Vibration Isolators

4.2.2 經結構傳遞的噪音的控制

如機電設備固定在建築物上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

經結構傳遞的噪音通過加設避震器以承托機電設備，從而將機電設備與建築物結構隔離（參考圖 2 及附錄八）。

此外，如該機電設備運作上比較不穩定（例如抽氣扇或水泵），裝置浮動混凝土底座承托機電設備並置於避震器之上，可增加承托系統的堅硬度及穩定性（參考圖 2 及附錄七）。

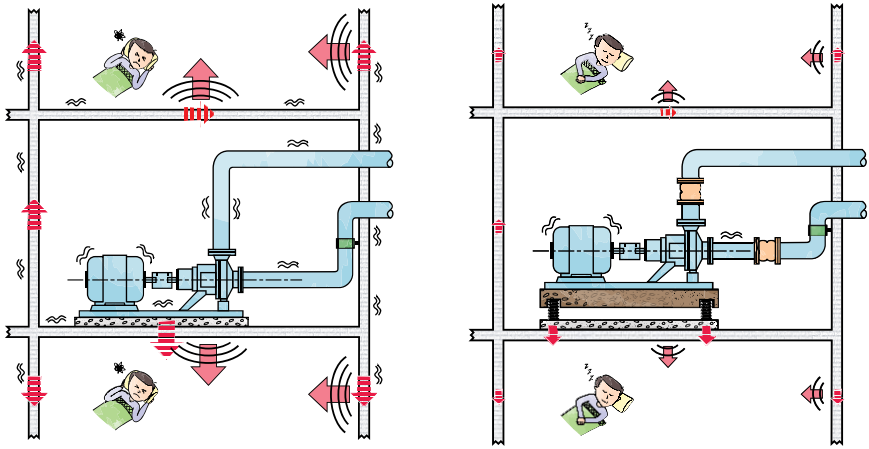


圖2： 以避震器控制經結構傳遞的噪音

5. Common Noise Problems and Practical Remedies

5.1. Ventilation Systems

5.1.1. Air-cooled Chillers

(A) Noise Problems

Air-borne Noise

Noise generated from air-cooled chillers may cause disturbance to nearby residents (see Figure 3). It mainly comes from the air flow noise resulting from air turbulence at condenser caused by the blowers and compressor noise during running and on/off compression cycle of refrigerant.

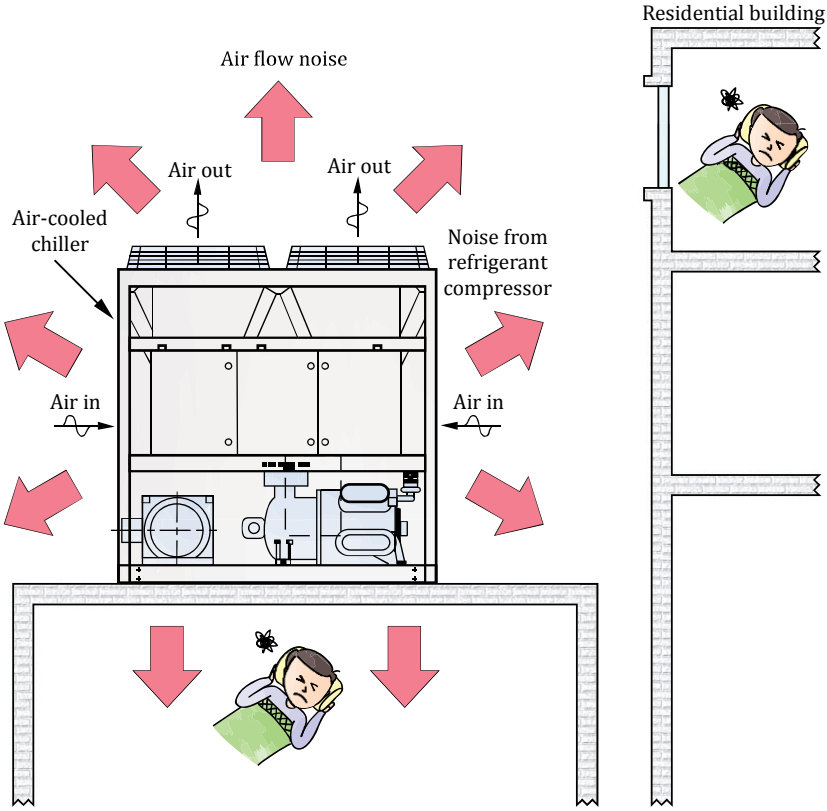


Figure 3 : Air-borne Noise from Air-cooled Chillers

5. 常見噪音問題及實用矯正法

5.1. 通風系統

5.1.1. 風冷式冷卻器

(A) 噪音問題

經空氣傳遞的噪音

風冷式冷卻器的噪音可對其附近的居民造成噪音騷擾（參考圖 3），其噪音主要來自冷凝器風扇上形成的湍流所產生的空氣流動噪音及在冷媒運行及開關時的壓縮器噪音。

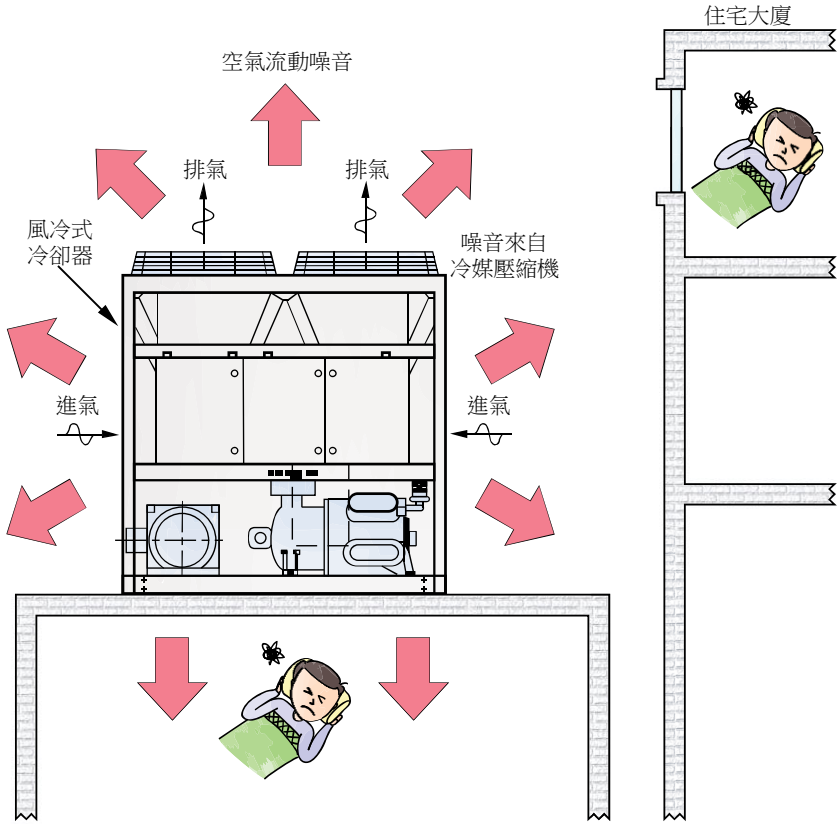


圖3： 經空氣傳遞的風冷或冷卻器噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from an air-cooled chiller's operation may be transmitted through building structure at points where the chiller is connected to the structure. The situation could be particularly worse when it is rigidly fixed to the structure without proper isolation (see Figure 4). The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

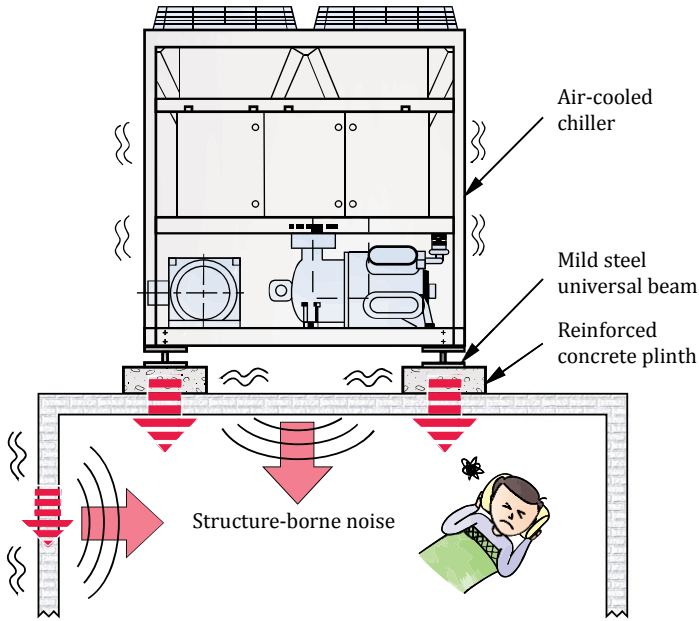


Figure 4 : Structure-borne Noise from Air-cooled Chillers

(A) 噪音問題（續）

經結構傳遞的噪音

如風冷式冷卻器固定在建築物上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內（參考圖 4）。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

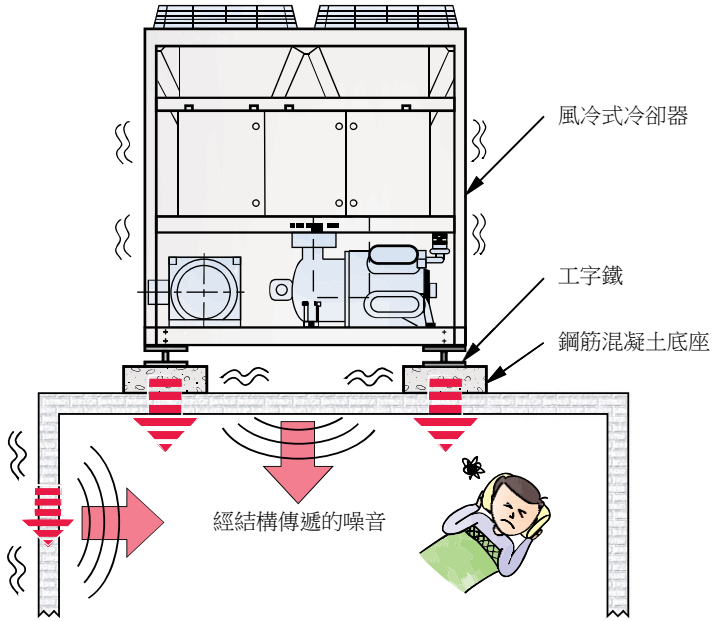


圖 4： 經結構傳遞的風冷式冷卻器噪音

(B) Practical Remedies

Air-borne Noise

- Erect a barrier or partial enclosure (see Figure 5) between the plant and nearby residential buildings so as to block the noise propagation path (see Appendix VI and Appendix V).

(Noise Reduction Up to 10 dB(A))

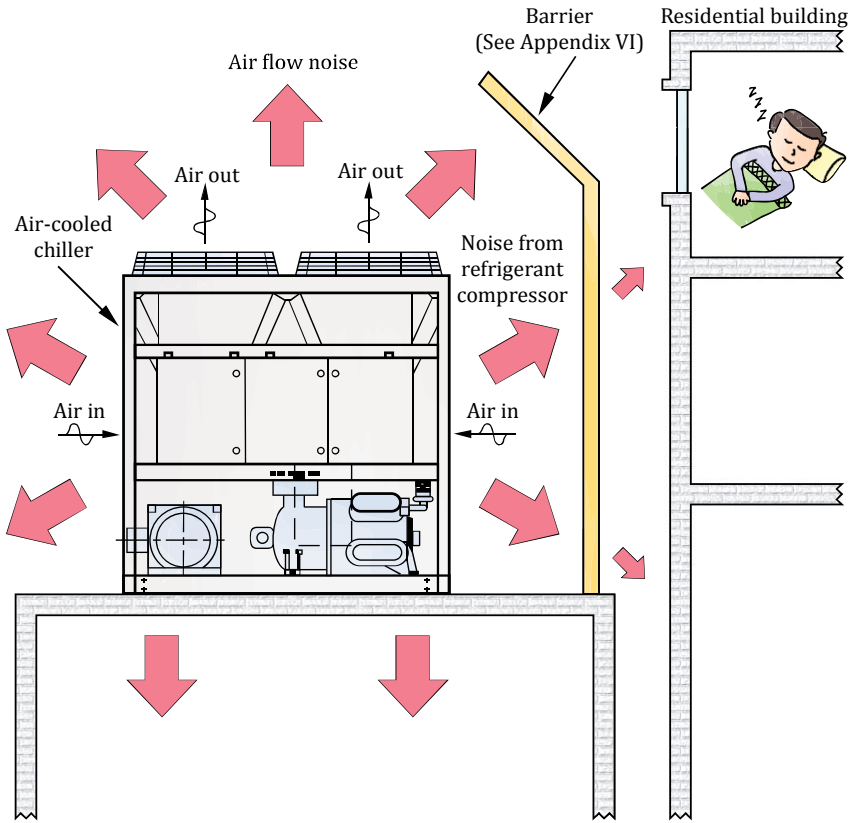


Figure 5 : Barrier for Air-cooled Chillers

(B)　實用矯正方法

<u>經空氣傳遞的噪音</u>

- 在機械設備與附近住宅大廈之間加設隔音屏障或局部隔音罩（參考圖 5）以阻礙噪音之傳遞（參考附錄六及附錄五）。

（噪音消減可達至 10 分貝(A)）

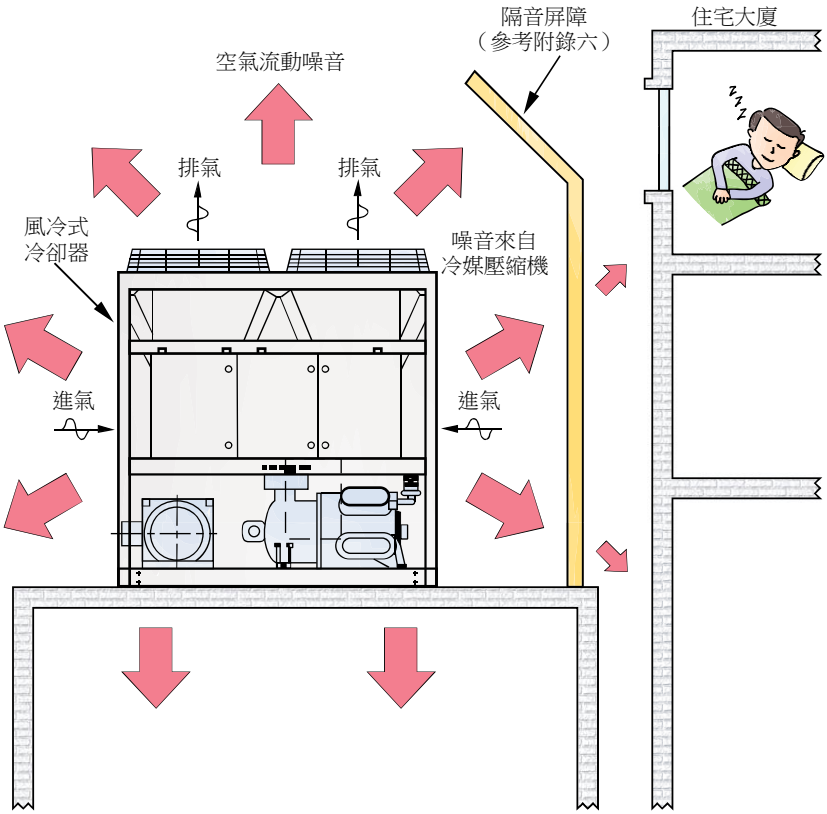


圖 5：　應用於風冷式冷卻器的隔音屏障

(B) Practical Remedies (Con't)

- Fabricate a complete enclosure with silencers at condenser fan outlets and at air inlets of the enclosure (see Figure 6) so as to contain and absorb the noise from the chiller when there are noise sensitive receivers all around (see Appendix IV).

- Install floating floor (see Figure 6) so as to reduce air-borne noise transmission through floor slab when the floor underneath is a noise sensitive receiver (see Appendix X).

(Noise Reduction Up to 30 dB(A))

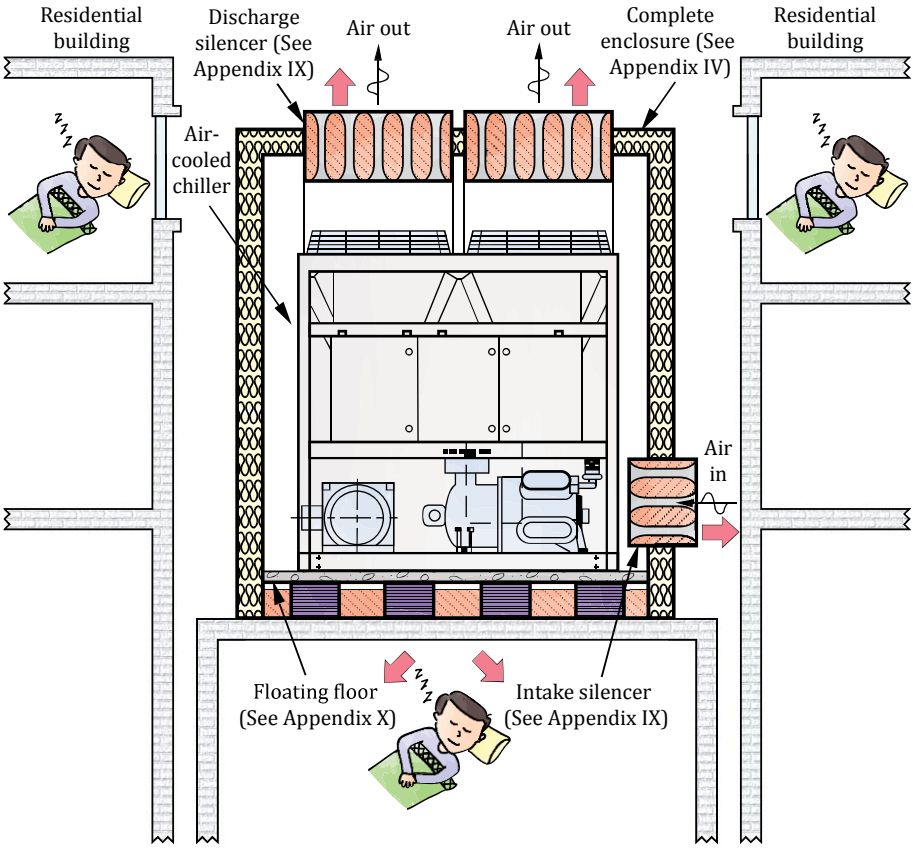


Figure 6 : Floating Floor and Complete Enclosure for Air-cooled Chillers

(B)　實用矯正方法（續）

- 當「噪音感應強的地方」位於四週，應建造完全隔音罩附以消聲器於冷凝器風扇的排氣口和隔音罩進氣口（參考圖 6）以圍封和吸收冷卻器的噪音（參考附錄四）。

- 當下層為「噪音感應強的地方」時，安裝浮動地台（參考圖 6）以減低通過地板而經空氣傳遞的噪音（參考附錄十）。

（噪音消減可達至 30 分貝(A)）

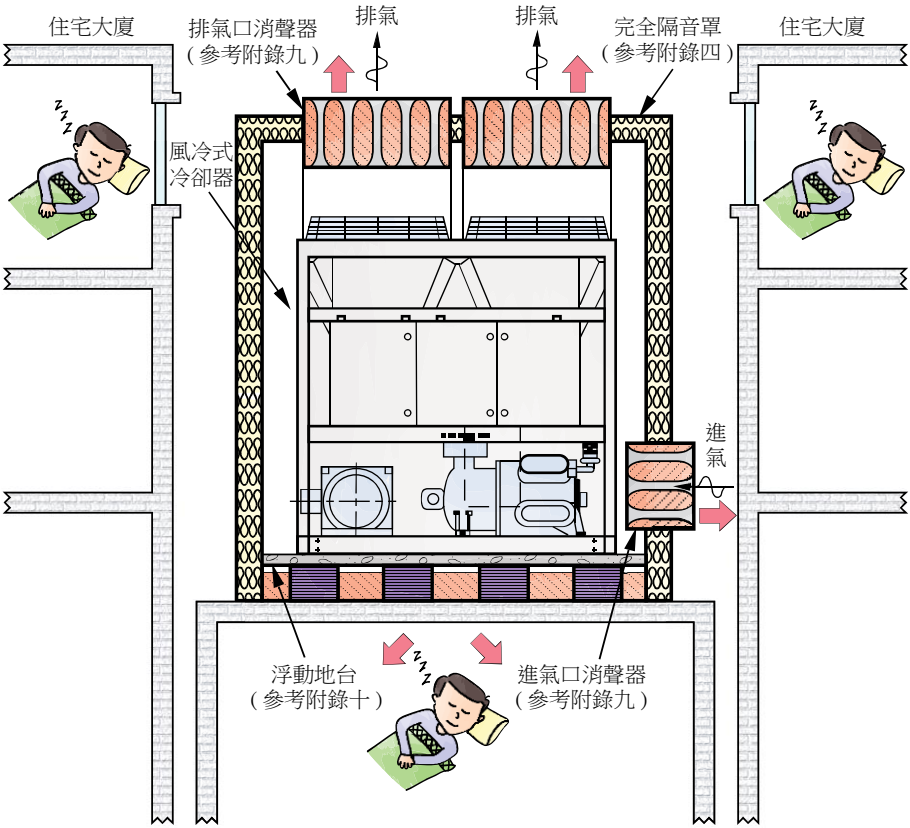


圖 6：　應用於風冷式冷卻器的浮動地台及完全隔音罩

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide vibration isolators to support an air-cooled chiller (see Figure 7), thereby isolating it from the building structure (see Appendix VIII).

(Noise Reduction Up to 20 dB(A))

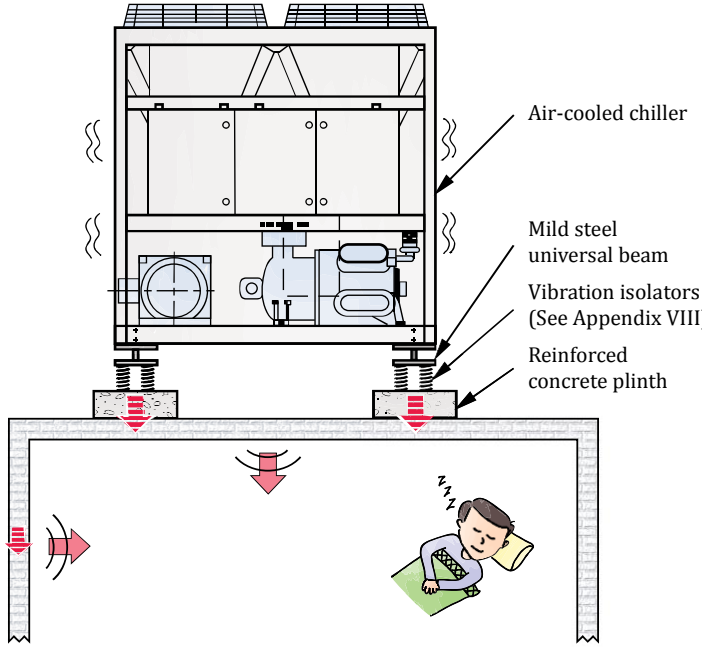


Figure 7 : Vibration Isolation of Air-cooled Chillers

(B)　實用矯正方法（續）

經結構傳遞的噪音

- 裝置避震器以承托風冷式冷卻器（參考圖 7），從而將冷卻器與建築物結構隔離（參考附錄八）。

(噪音消減可達至 20 分貝(A))

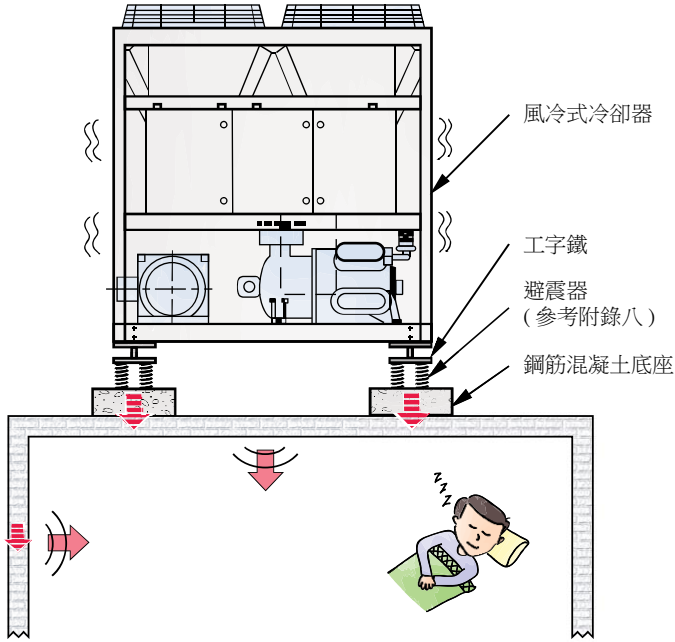


圖 7：　風冷式冷卻器的隔震

5.1.2. Water Cooling Towers

(A) Noise Problems

Air-borne Noise

Noise generated from water cooling towers may cause disturbance to nearby residents (see Figure 8). It mainly comes from the air flow noise resulting from air turbulence at condenser fans and water splashing noise due to water flowing through the tower into the collection basin.

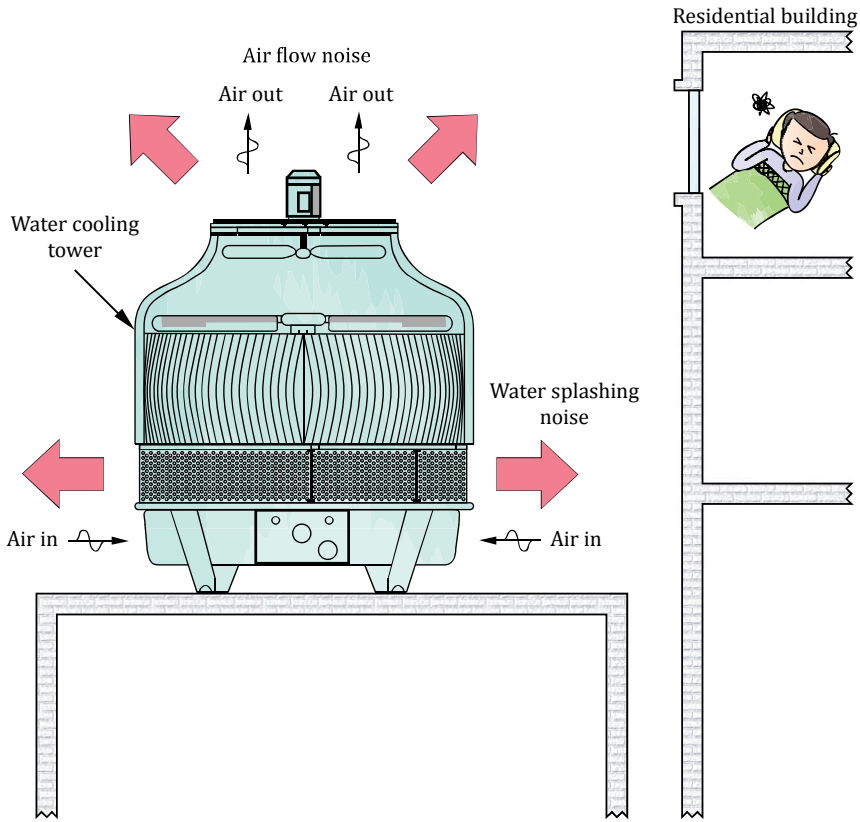


Figure 8 : Air-borne Noise from Water Cooling Towers

5.1.2. 冷卻水塔噪音

(A) 噪音問題

經空氣傳遞的噪音

冷卻水塔所產生的噪音可對其附近居民造成噪音騷擾（參考圖 8），其噪音主要來自冷凝器風扇上形成的湍流所產生的空氣流動噪音及水濺潑到收集水池而產生的噪音。

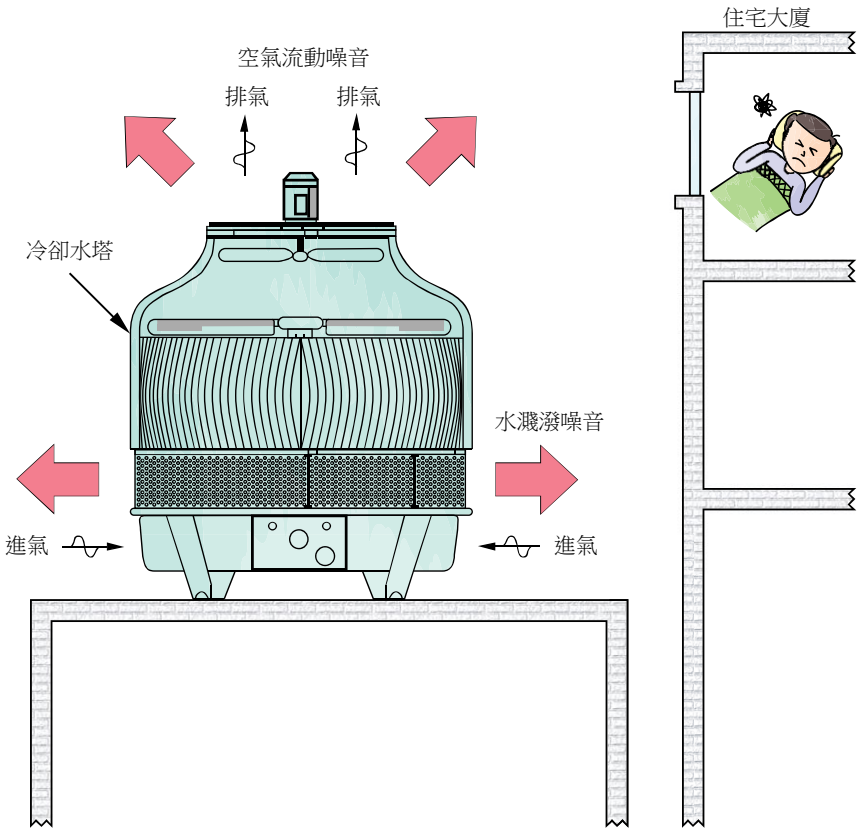


圖 8： 經空氣傳遞的冷卻水塔噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from a water cooling tower's operation may be transmitted indoors through building structure at points where the cooling tower is rigidly fixed to the structure without proper isolation (see Figure 9). The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

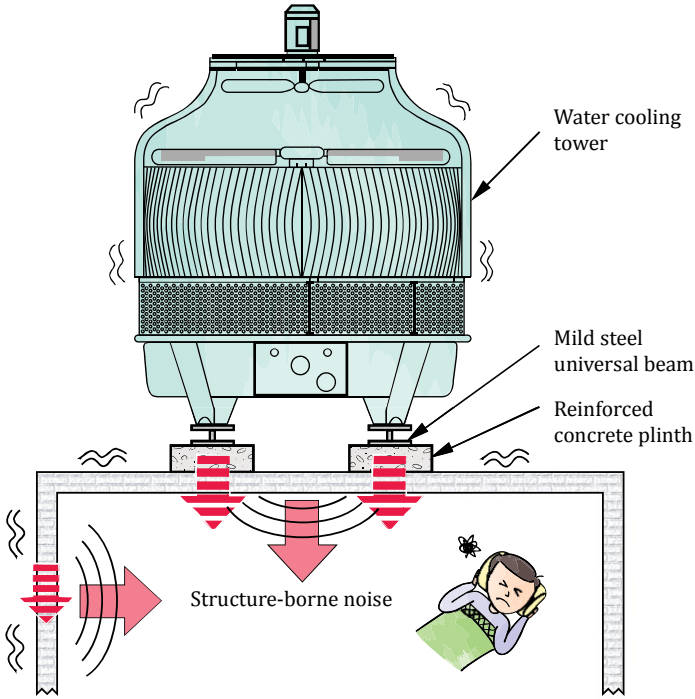


Figure 9 : Structure-borne Noise from Water Cooling Towers

(A) 噪音問題（續）

經結構傳遞的噪音

如冷卻水塔固定在建築物上而沒有隔離，其運行時所產生的震動可經建築物結構傳至室內（參考圖 9）。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

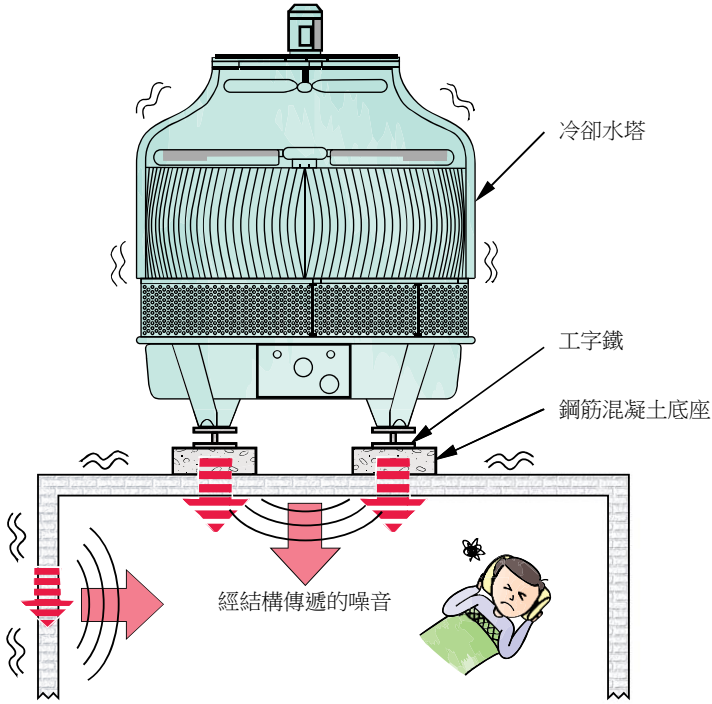


圖 9： 經結構傳遞的冷卻水塔噪音

(B) Practical Remedies

Air-borne Noise

- Erect a barrier or partial enclosure between the plant and nearby residential buildings so as to block the noise propagation path (see Appendix VI and Appendix V), provide an acoustic mat on the water surface so as to reduce the water splashing noise, and install acoustically lined vent cowl at fan discharge outlet (see Figure 10), if not much noise reduction is required.

(Noise Reduction Up to 10 dB(A))

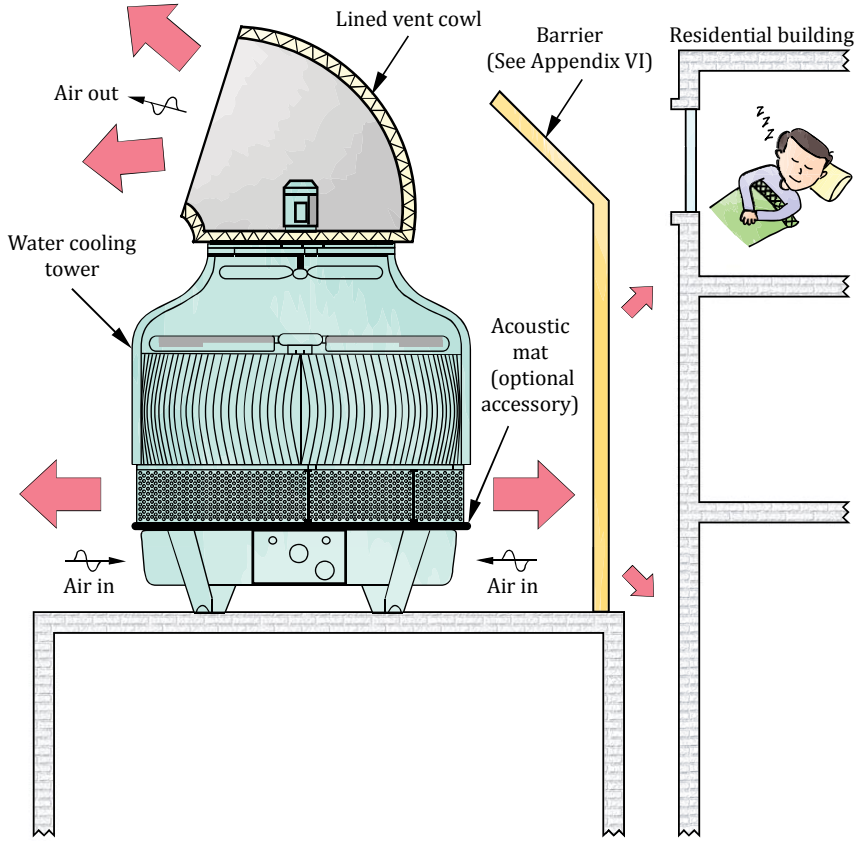


Figure 10 : Barrier and Vent Cowl for Water Cooling Towers

(B)　實用矯正方法

經空氣傳遞的噪音

- 假如所需的噪音消減並非太多，可在機械設備與附近住宅大廈之間加設隔音屏障或局部隔音罩以阻礙噪音之傳遞（參考附錄六及附錄五），在收集水池水面上裝置吸音蓆以減低水濺潑所發出的噪音，及安裝通風罩於抽氣扇排氣出口（參考圖 10）。

(噪音消減可達至 10 分貝(A))

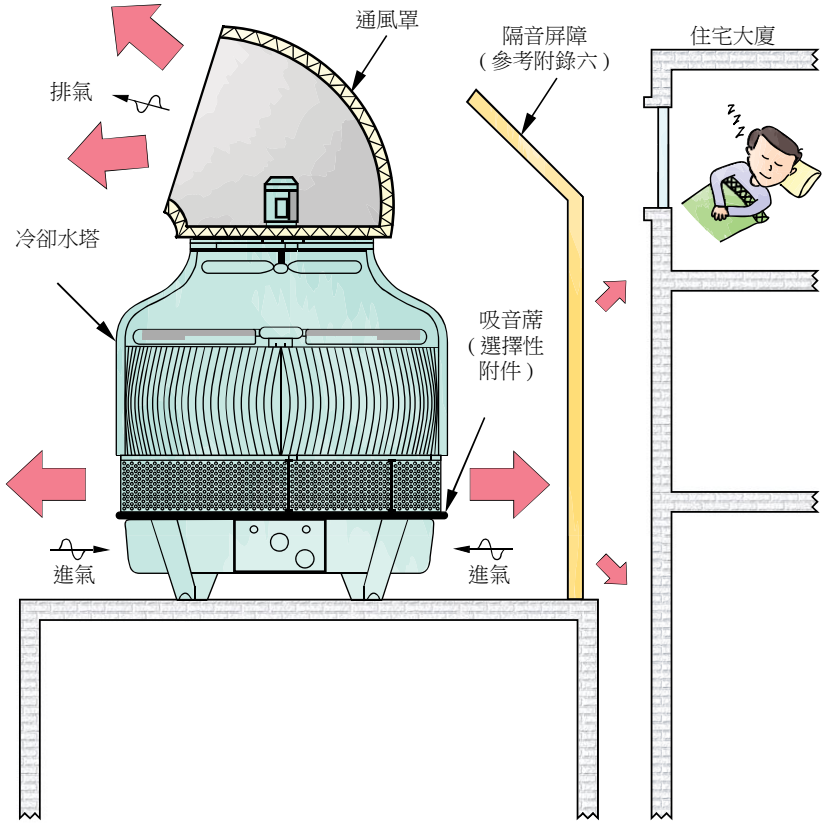


圖 10：　應用於冷卻水塔的隔音屏障及通風罩

(B) Practical Remedies (Con't)

- Fabricate a complete enclosure with silencers at condenser fan outlets and at air inlets of the enclosure (see Figure 11) so as to contain and absorb the noise from the water cooling tower (see Appendix IV) when there are noise sensitive receivers all around.

(Noise Reduction Up to 30 dB(A))

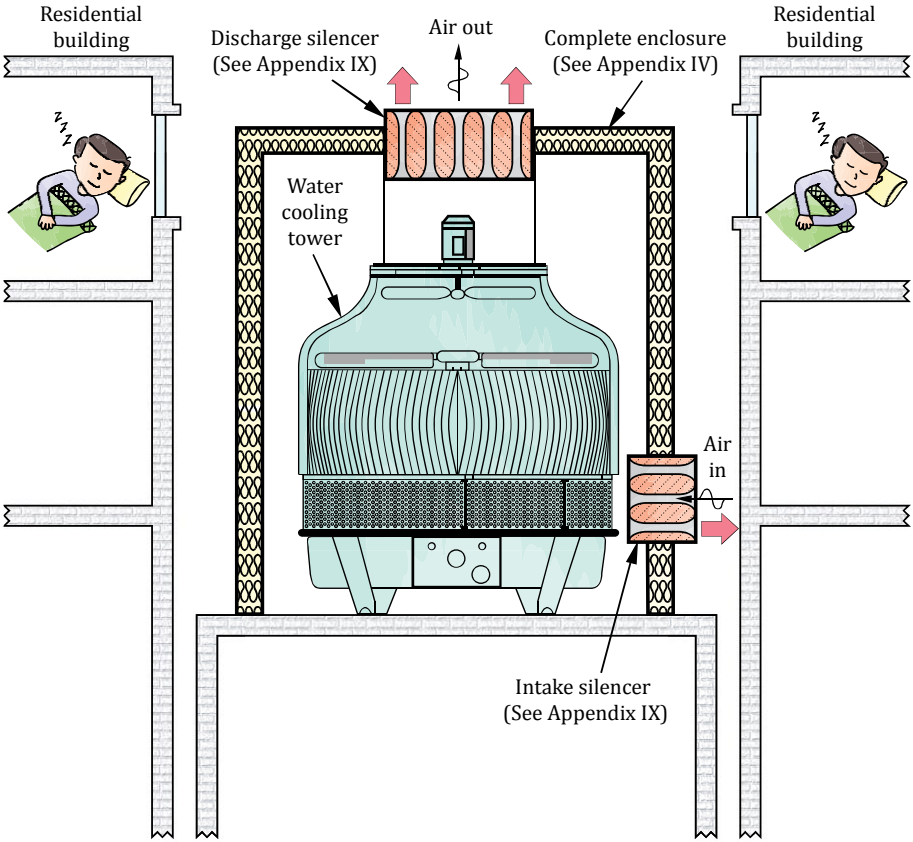


Figure 11 : Complete Enclosure for Water Cooling Towers

(B)　實用矯正方法（續）

- 當「噪音感應強的地方」位於四周，應建造完全隔音罩附以消聲器於冷凝器風扇的排氣口和隔音罩進氣口（參考圖11），以圍封和吸收冷卻水塔的噪音（參考附錄四）。

(噪音消減可達至30分貝(A))

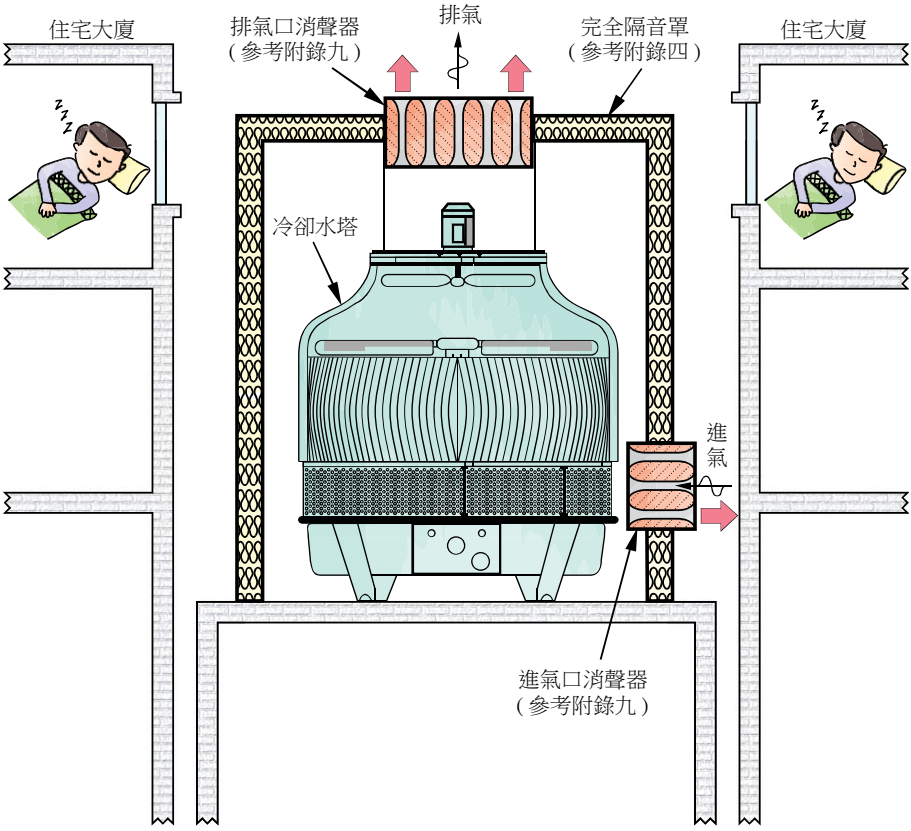


圖11：　應用於冷卻水塔的完全隔音罩

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide vibration isolators to support a water-cooling tower (see Figure 12), thereby isolating it from the building structure (see Appendix VIII).

(Noise Reduction Up to 20 dB(A))

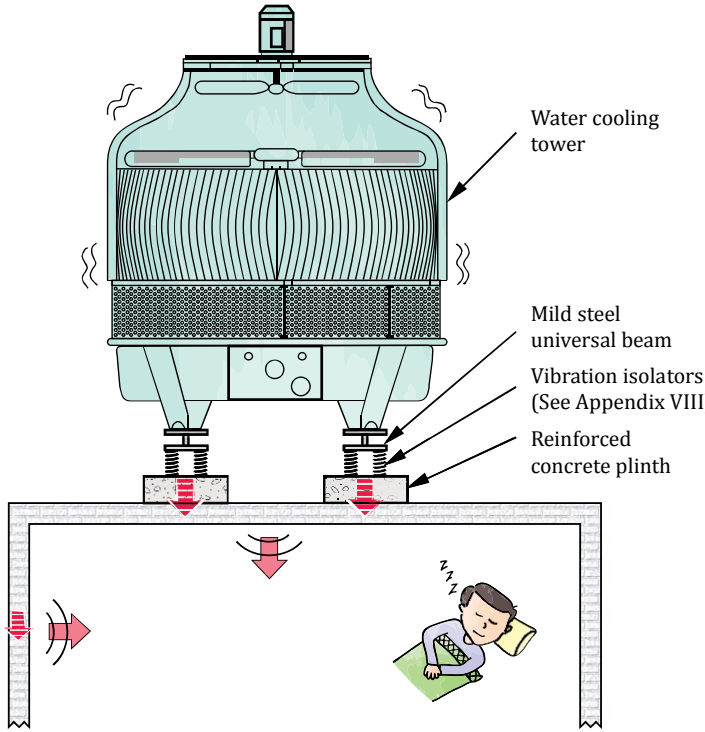


Figure 12 : Vibration Isolation of Water Cooling Towers

(B)　實用矯正方法（續）

<u>經結構傳遞的噪音</u>

- 裝置避震器以承托冷卻水塔（參考圖 12），從而將冷卻水塔與建築物結構隔離（參考附錄八）。

(噪音消減可達至 20 分貝(A))

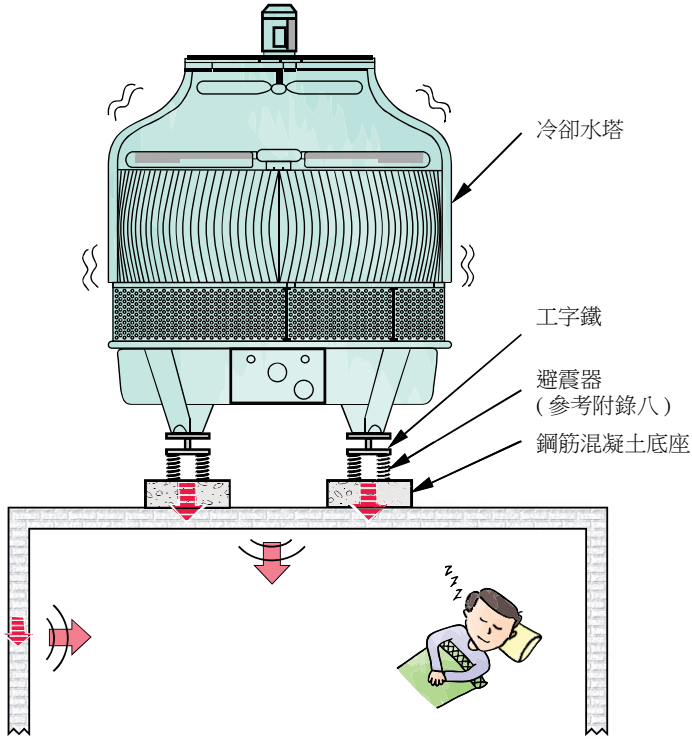


圖 12：　冷卻水塔的隔震

5.1.3. Fans

(A) Noise Problems

Air-borne Noise

The noise problem associated with fans may cause noise disturbance to nearby residents (see Figure 13). It mainly comes from the interaction of flow turbulence and solid surface of fan blades, and blade / fan vibration. The noise is transmitted upstream and downstream in the connecting ducts or to the atmosphere through the fan case.

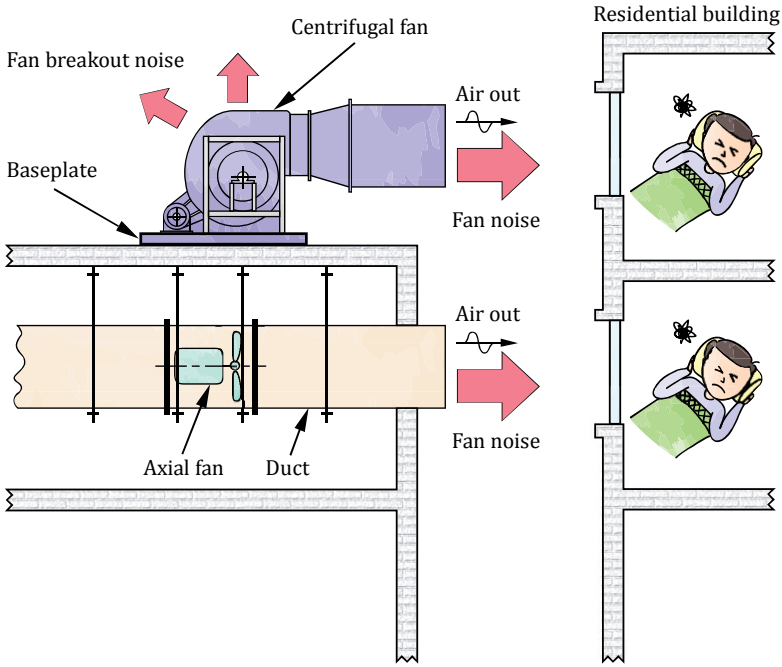


Figure 13 : Air-borne Noise from Axial and Centrifugal Fans

5.1.3. 抽氣扇

(A) 問題

經空氣傳遞的噪音

抽氣扇的噪音可對其附近居民造成噪音騷擾（參考圖 13），其噪音主要來自湍流和扇葉面的相互作用及扇葉或抽氣扇的震動。這些噪音可傳至相連的管道前方及後方或經抽氣扇外殼傳至大氣中。

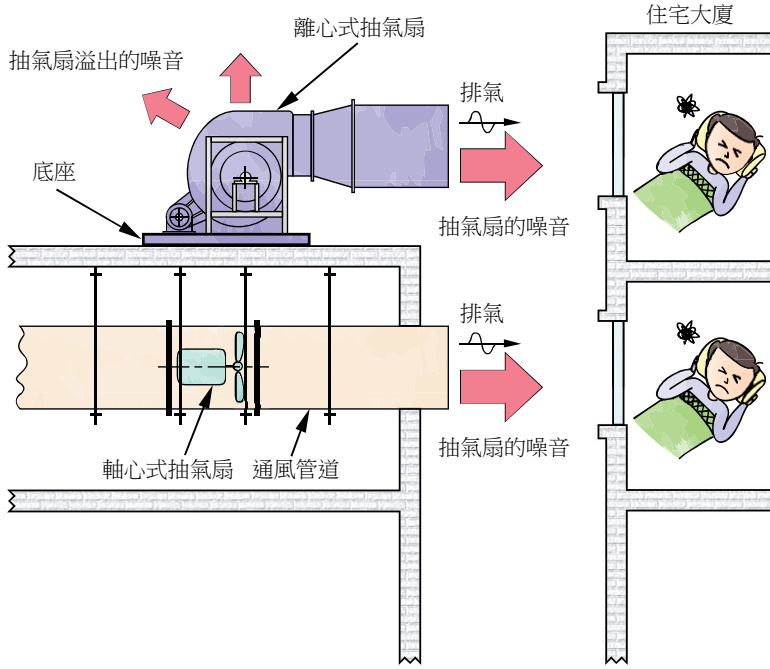


圖13： 經空氣傳遞的軸心式及離心式抽氣扇噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from an operating fan may be transmitted to the interior of the building through building structure when the fan is directly mounted on a supporting structure without proper isolation (see Figure 14). The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

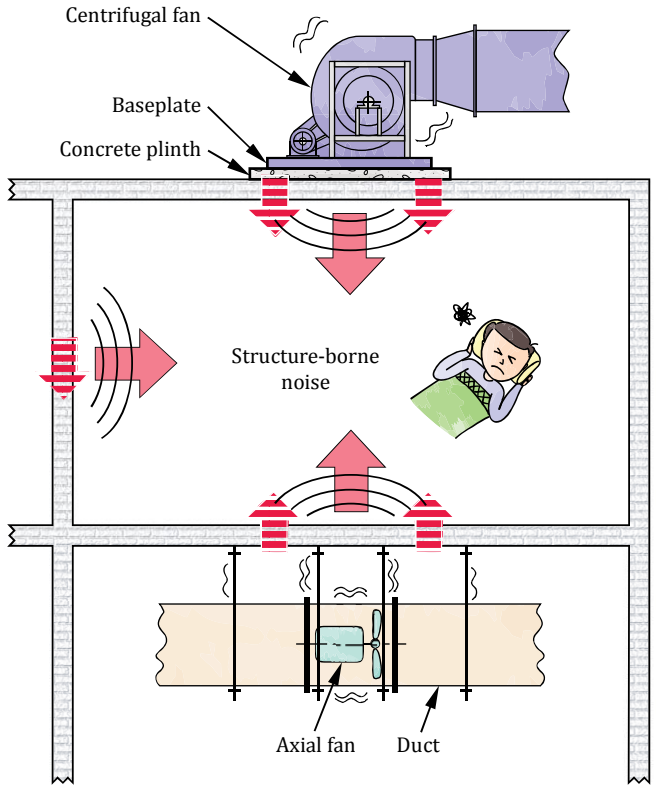


Figure 14 : Structure-borne Noise from Axial and Centrifugal Fans

(A) 噪音問題（續）

經結構傳遞的噪音

當抽氣扇直接繫於支架結構上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內（參考圖 14）。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

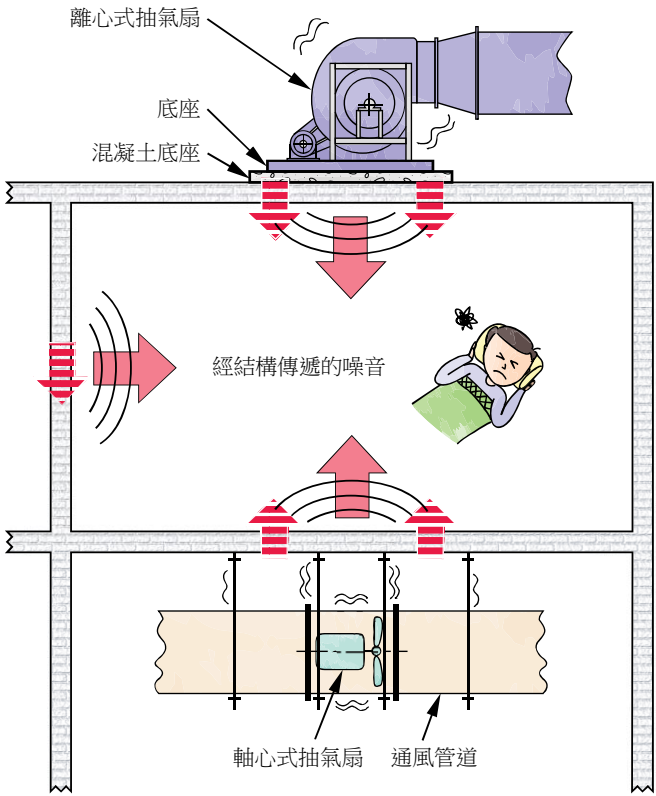


圖 14： 經結構傳遞的軸心式及離心式抽氣扇噪音

(B) Practical Remedies

Air-borne Noise

- Reduce the speed of fans at non-rushed hours.
- Divert duct openings away from receivers (see Figure 15).

(Noise Reduction up to 5 dB(A))

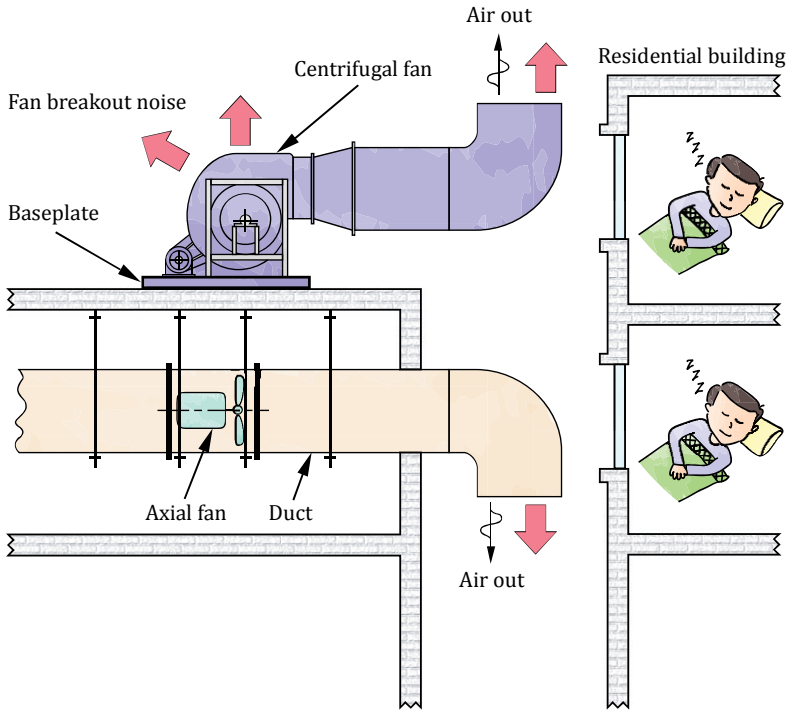


Figure 15 : Duct Diversion

(B)　實用矯正方法

<u>經空氣傳遞的噪音</u>

- 在非繁忙時間減低抽氣扇的運行轉速。
- 使通風管道轉向以遠離接收者（參考圖 15）。

(噪音消減可達至 5 分貝(A))

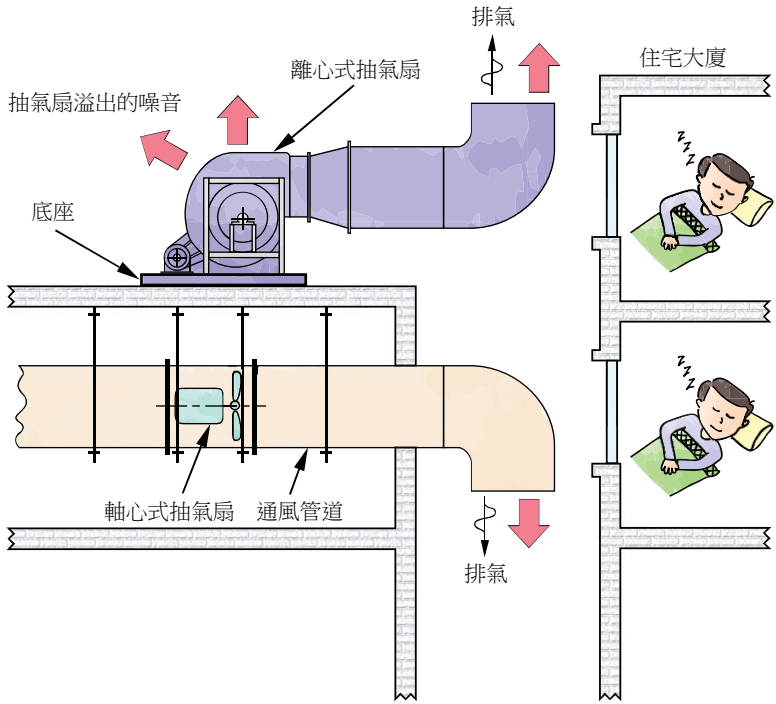


圖 15：　通風管道轉向

(B) Practical Remedies (Con't)

- Install a silencer at air discharge point of a fan (see Figure 16) so as to absorb noise generated from the fan (see Appendix IX).
- Fabricate a complete enclosure (see Figure 16) to contain and absorb the noise energy radiated by the source (see Appendix IV).

(Noise Reduction up to 30 dB(A))

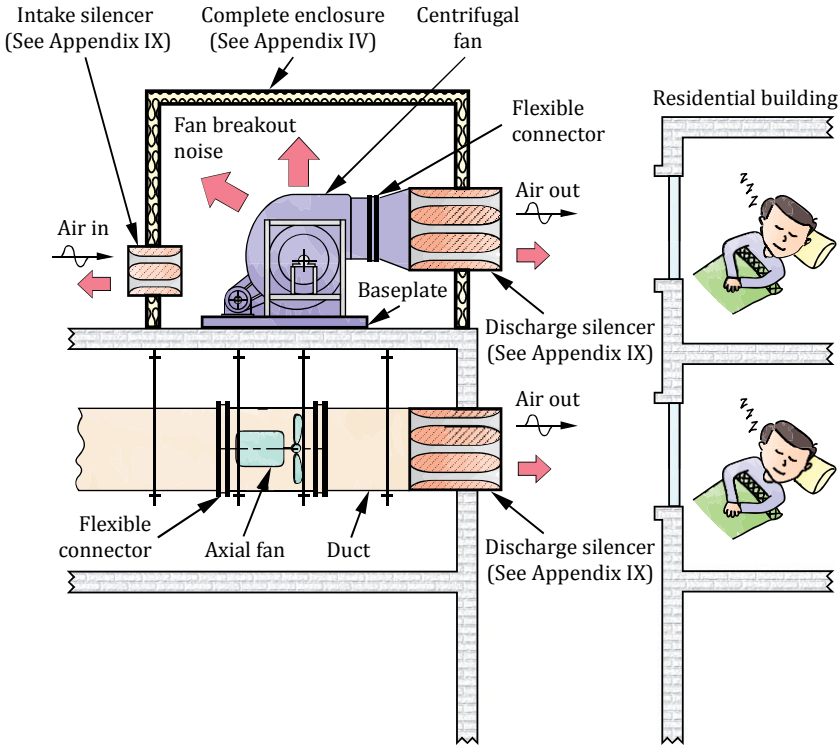


Figure 16 : Complete Enclosure and Silencers for Axial and Centrifugal Fans

(B)　實用矯正方法（續）

- 安裝消聲器於抽氣扇的排氣口（參考圖 16），從而吸收抽氣扇所產生的噪音（參考附錄九）。
- 建造完全隔音罩（參考圖 16）用以圍封和吸收噪音源所產生的噪音（參考附錄四）。

(噪音消減可達至 30 分貝(A))

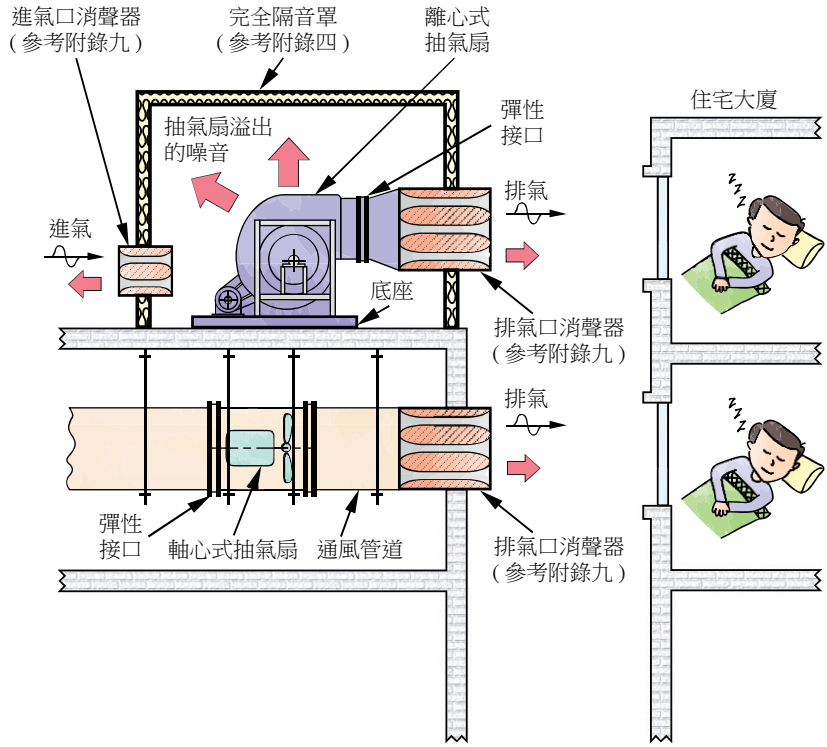


圖 16：　應用於軸心式和離心式抽氣扇的完全隔音罩及消聲器

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide an inertia block to support the fan (see Figure 17) so as to add rigidity and stability to the ventilation system (see Appendix VII), and provide vibration isolators to support the inertia block (see Figure 17), thereby isolating it from the building structure (see Appendix VIII).
- Provide flexible connectors between the fan and associated ducts (see Figure 17), thereby isolating it from the ductwork.

(Noise Reduction up to 20 dB(A))

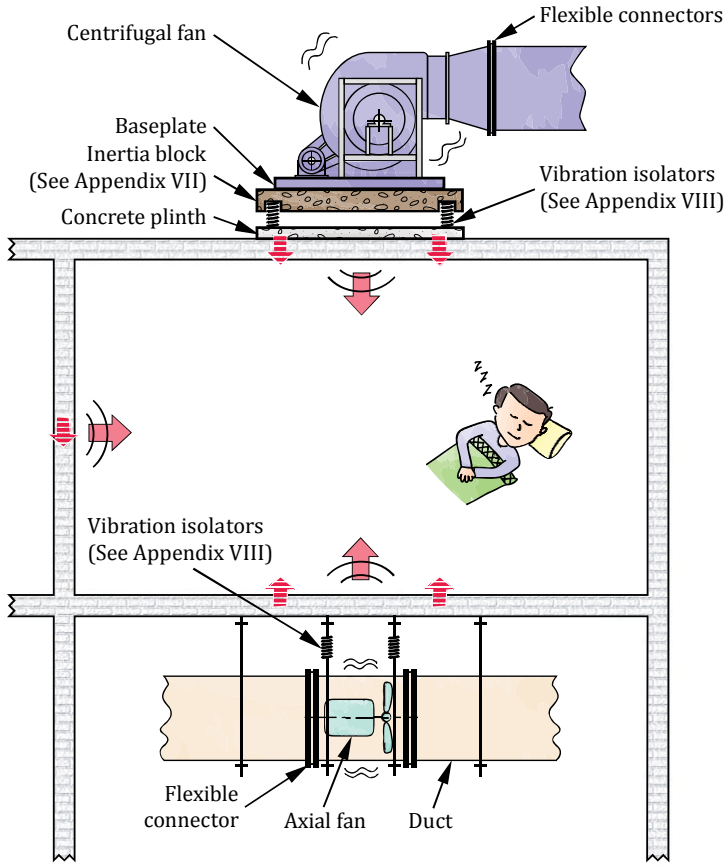


Figure 17 : Vibration Isolation of Axial and Centrifugal Fans

(B)　實用矯正方法（續）

經結構傳遞的噪音

- 裝置浮動混凝土底座以承托抽氣扇（參考圖 17），從而增加該通風系統的堅硬度及穩定性（參考附錄七），及裝置避震器以承托浮動混凝土底座（參考圖 17），使其與建築物結構隔離（參考附錄八）。
- 在抽氣扇及通風管道之間裝置彈性接口，使其與通風管道隔離（參考圖 17）。

(噪音消減可達至 20 分貝(A))

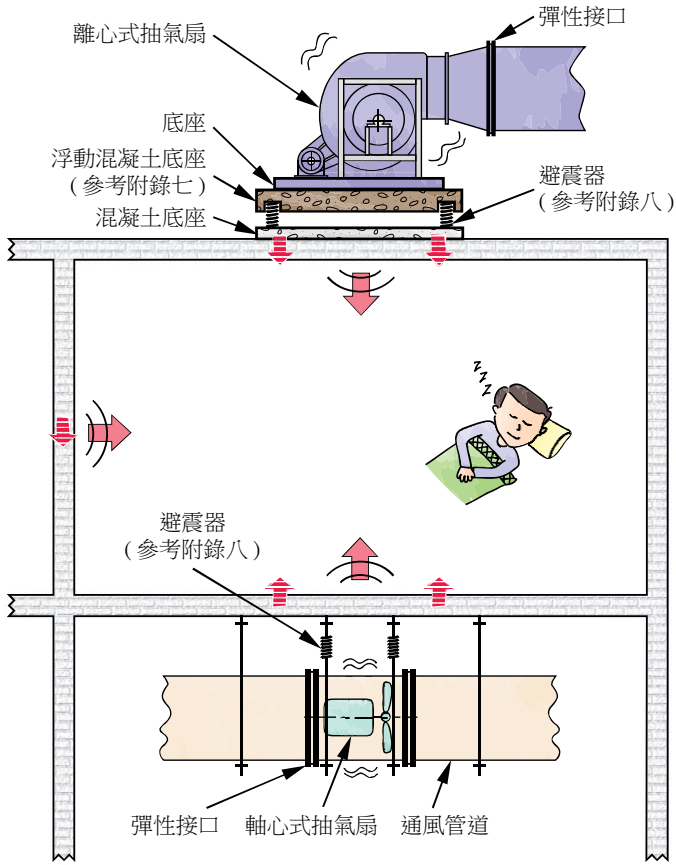


圖 17：　軸心式及離心式抽氣的隔震

5.1.4. Ducts

(A) Noise Problems

Air-borne Noise

Air flowing through ducts induces vibration at the duct wall, which generates rumbling noise. In addition, the noise inside the duct can be transmitted to the atmosphere through the duct surface. All of these may cause noise disturbance to nearby residents (see Figure 18).

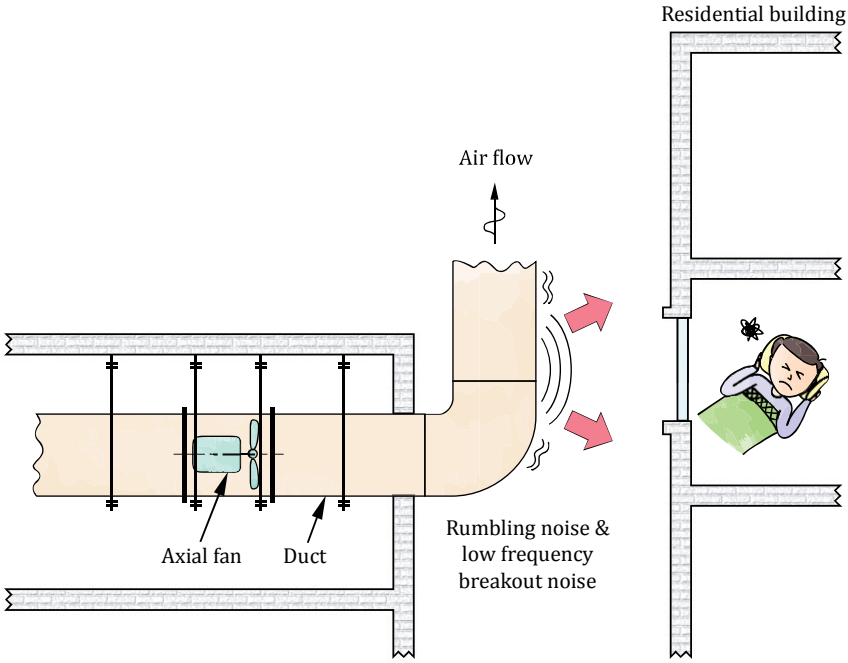


Figure 18 : Duct Noise

5.1.4. 通風管道

(A) 噪音問題

經空氣傳遞的噪音

空氣在通風管道內流動引致管道壁震動，從而發出隆隆聲的噪音。另外通風管道內的噪音也可經由通風管道表面傳至大氣中。這些噪音可對附近居民造成噪音騷擾（參考圖 18）。

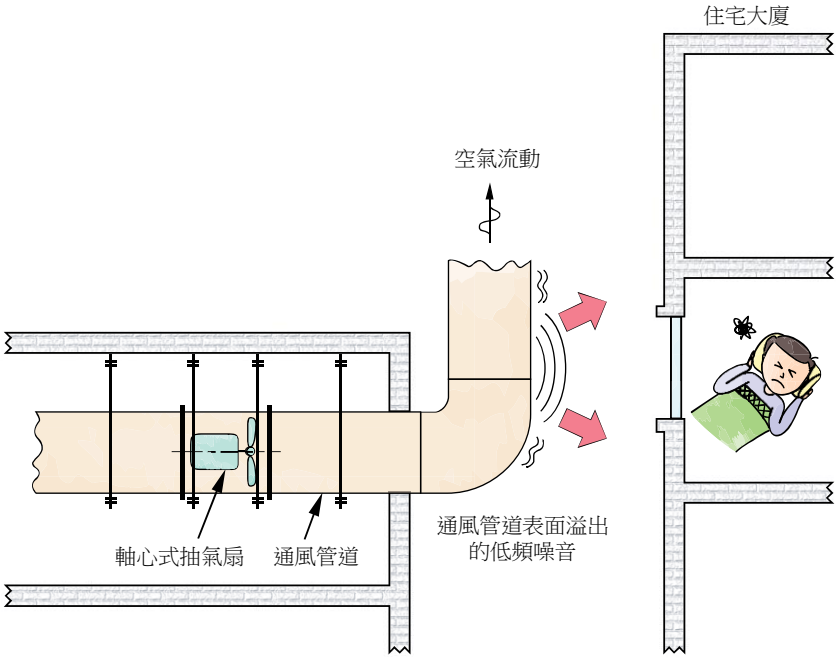


圖 18： 通風管道的噪音

(B) Practical Remedies

Air-borne Noise

- Stiffen the vibrating duct surface with supporting webs so as to reduce the movement of the vibrating surface.
- Apply damping material to the vibrating duct surface (see Figure 19) so as to reduce the movement of vibrating surface.
- Apply composite lagging of sound absorbing materials (see Figure 19) to contain the radiation of noise.

(Noise Reduction up to 20 dB(A))

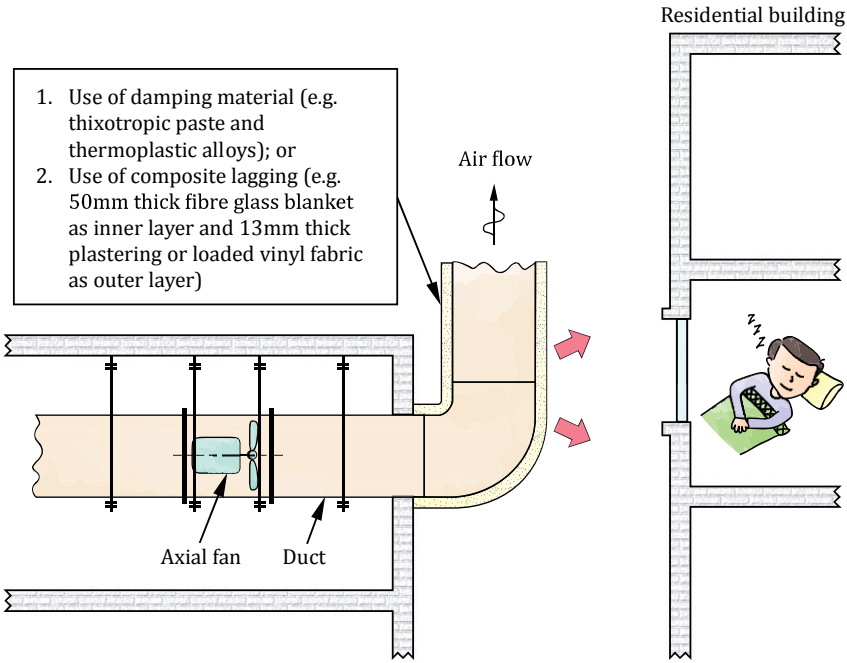


Figure 19 : Use of Damping Compound and Composite Lagging

(B)　實用矯正方法

<u>經空氣傳遞的噪音</u>

- 用承托蹼使震動的通風管道表面堅硬，從而減低其表面的震動。
- 在震動的通風管道表面加上具阻尼減震的材料（參考圖19），從而減少震動面的移動。
- 採用具吸音材料的合成橫擋板以圍封散發出的噪音（參考圖 19）。

(噪音消減可達至 20 分貝(A))

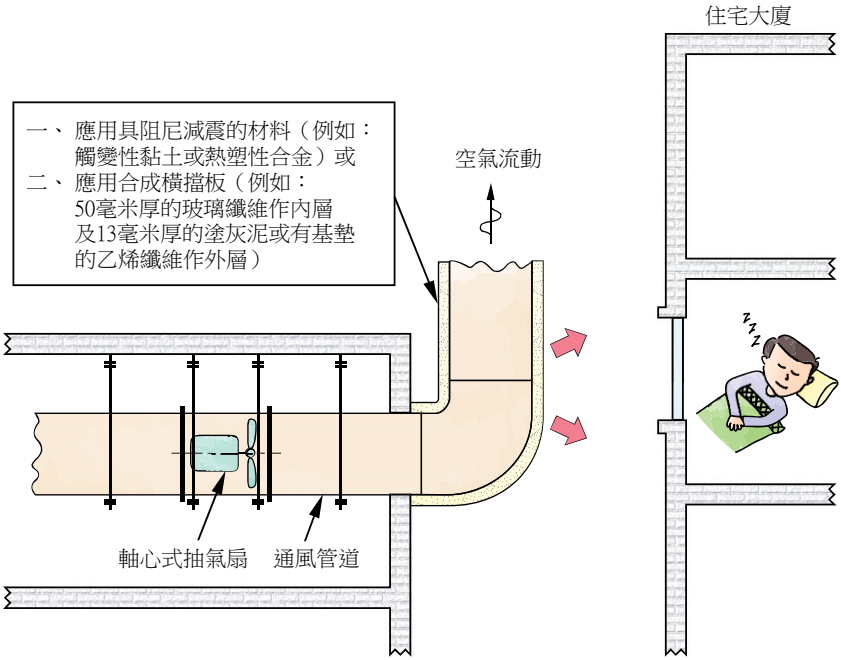


圖 19：　具阻尼減震的合成物和合成橫擋板的應用

5.2. Pumping Systems

5.2.1. Pipes

(A) Noise Problems

Air-borne Noise

Water flows in a pipe causing vibration at the pipe wall and generating broadband noise which may cause noise disturbance to nearby residents (see Figure 20). When the water flow changes direction suddenly because of obstacles in the pipe such as sharp bends or valves, a loud noise is generated which becomes louder with increasing water flow rate and pipe size.

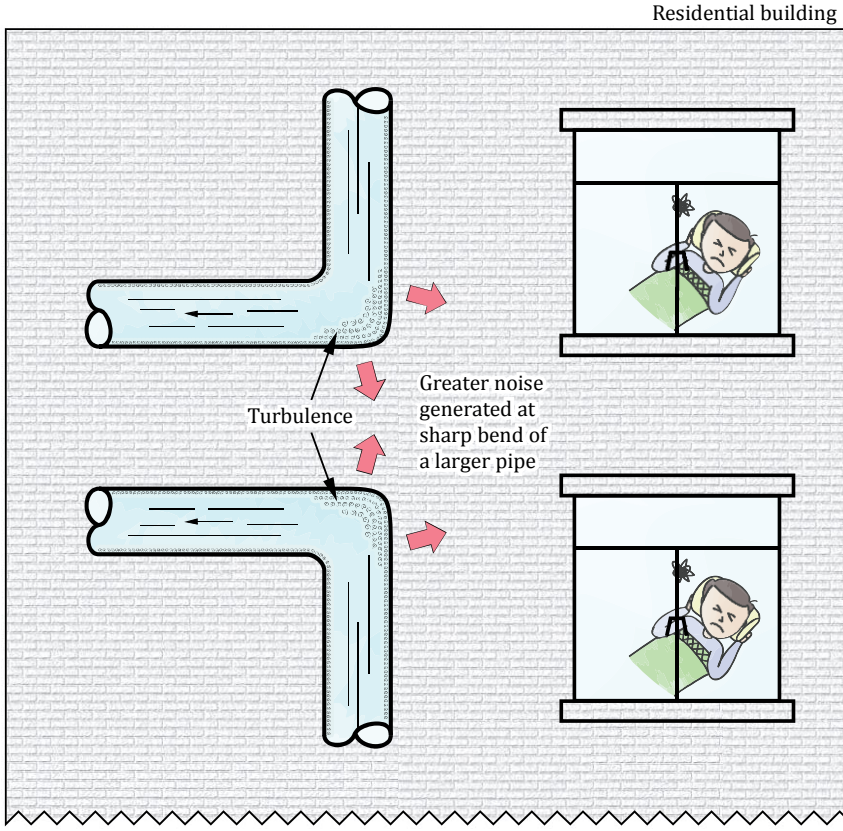


Figure 20 : Noise from Ringing Pipes

5.2. 抽水系統

5.2.1. 喉管

(A) 噪音問題

經空氣傳遞的噪音

水在喉管內流動引致管壁震動而散發的寬頻噪音可對附近的居民造成噪音騷擾（參考圖 20）。水流因喉管內的障礙物（例如：急變的彎位或閥）而須突然改變流向將產生很大的噪音，而噪音會隨水流量增加和喉管增大而增大。

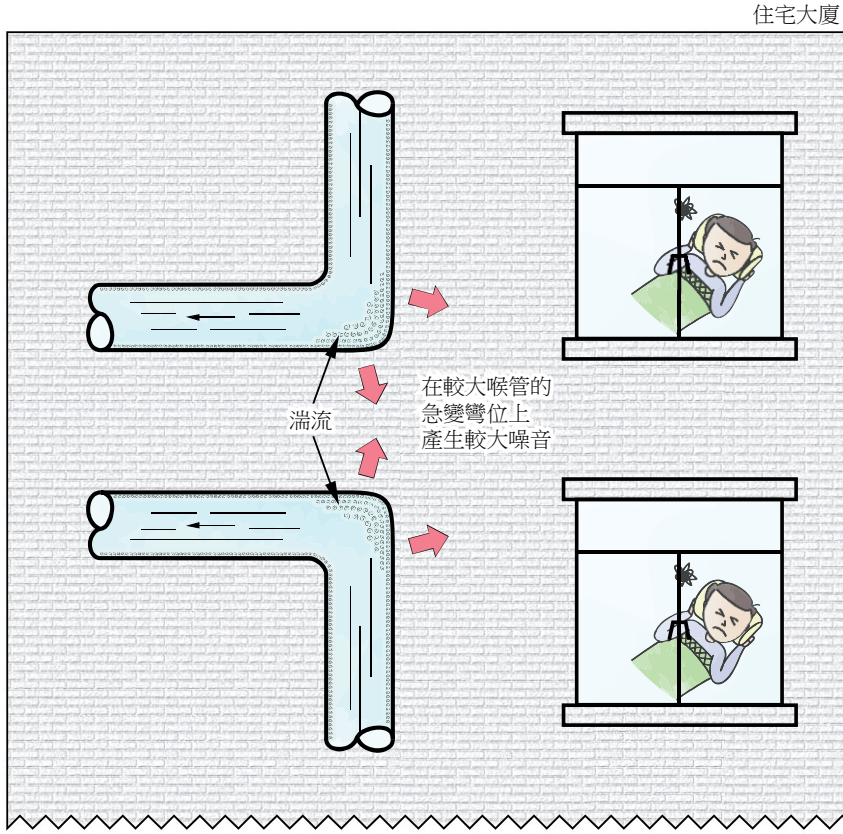


圖 20： 喉管的鐘鳴噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from the water flow in pipes may be transmitted from the pipe runs to the interior of the building through building structure where the pipes are mounted. It becomes more severe when the pipes are in direct contact with large planes such as walls or slabs (see Figure 21). The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

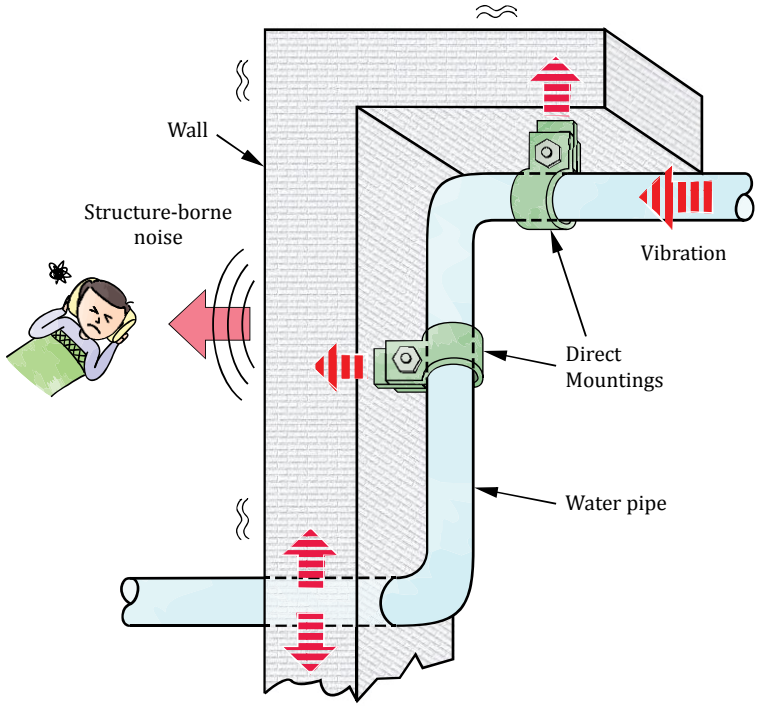


Figure 21 : Noise from Vibrating Pipes

(A) 噪音問題（續）

經結構傳遞的噪音

水在喉管內流動而產生之震動可經連繫喉管的建築物結構傳至室內。假若喉管與較大平面（例如：牆壁或地台）有直接接觸，震動將更趨嚴重（參考圖 21）。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

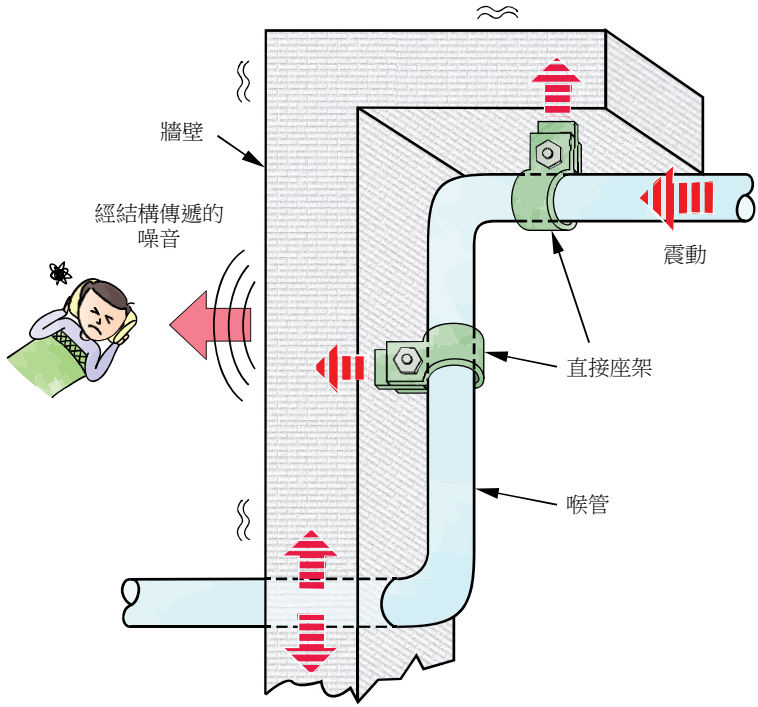


圖 21： 經結構傳遞的喉管噪音

(B) Practical Remedies

Air-borne Noise

- Use pipes with larger radius bends (see Figure 22) so as to minimize vibration of pipe walls.
- Use rigid mountings around the bend with suitable vibration isolators (see Figure 22) to minimize pipe vibration.
- Apply pipe lagging to damp the pipe ringing noise (see Figure 22).
- Use a larger pipe or adjust water flow velocities to below 2m/sec to minimize pipe vibration.

(Noise Reduction Up to 10 dB(A))

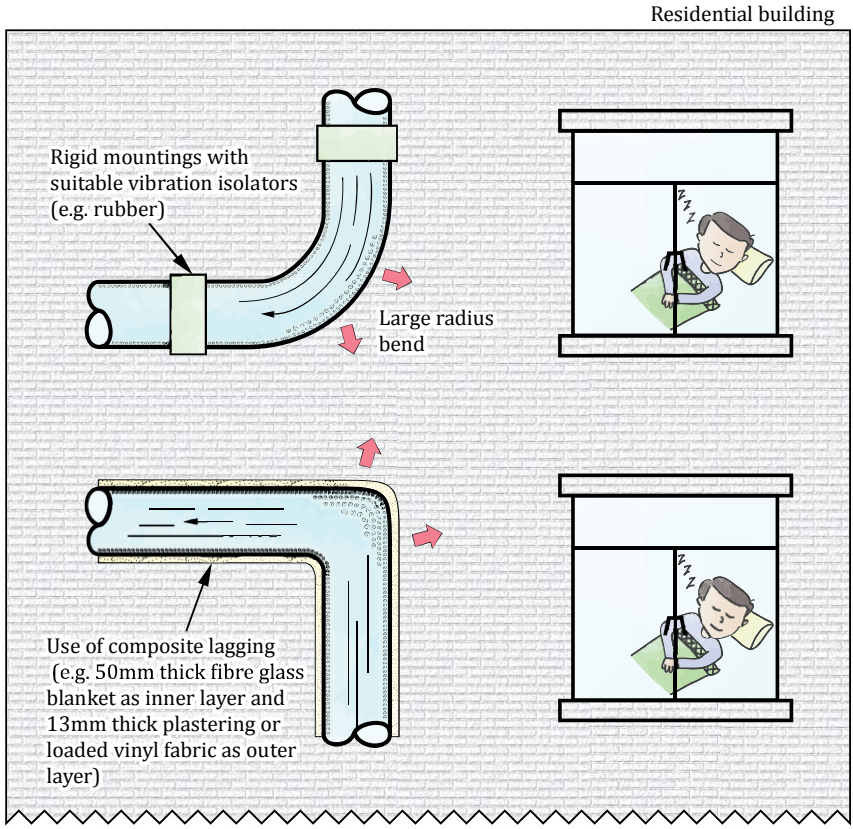


Figure 22 : Large Radius Bend and Pipe Lagging

(B)　實用矯正方法

經空氣傳遞的噪音

- 利用較大半徑的喉彎位（參考圖 22）以減低喉壁的震動。
- 利用配備適當避震器的堅硬座架固定喉管彎位（參考圖 22）以減低喉管震動。
- 採用喉管橫擋板以減弱喉管的鐘鳴噪音（參考圖 22）。
- 採用較大喉管或調校水流速度至低於每秒 2 米，以減低喉管震動。

(噪音消減可達至 10 分貝(A))

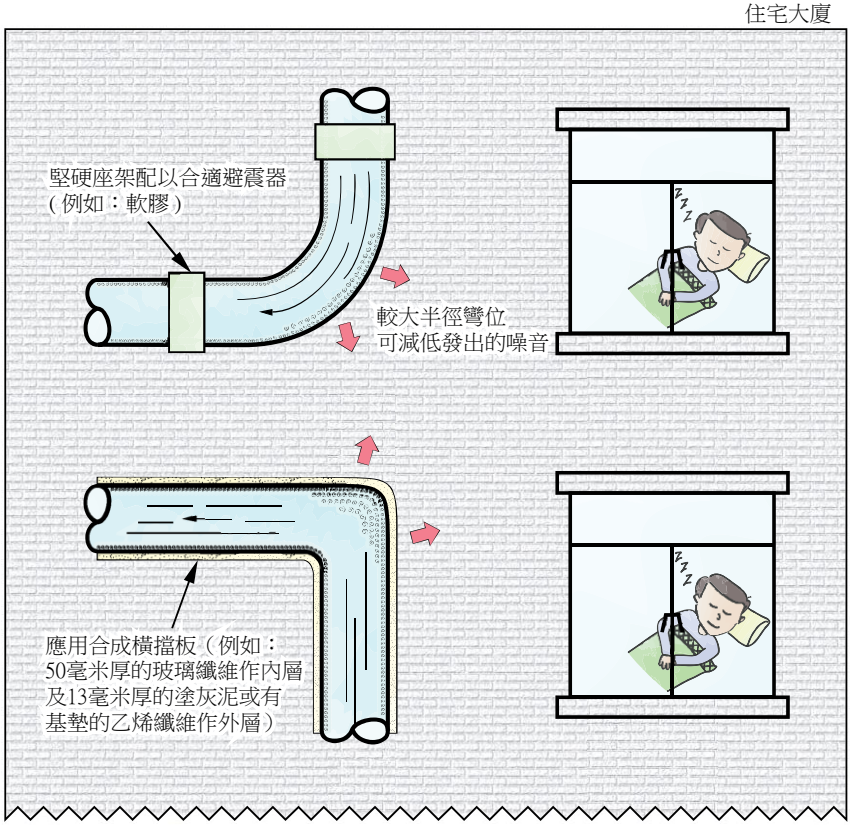


圖 22：　較大半徑的彎位和喉管橫擋板

(B) Practical Remedies (Con't)

Structure-borne Noise

- Use vibration isolators for attaching pipes to walls, ceilings or floors (see Figure 23), thereby isolating them from the building structure.
- Isolate pipes where they penetrate the slabs and walls by compressible materials, such as rubber sleeve or glass fibre packing (see Figure 23), thereby isolating them from the building structure.
- Install pressure reducing valves to regulate water pressure and hence the water flow, thereby reducing vibration of pipes.

(Noise Reduction Up to 20 dB(A))

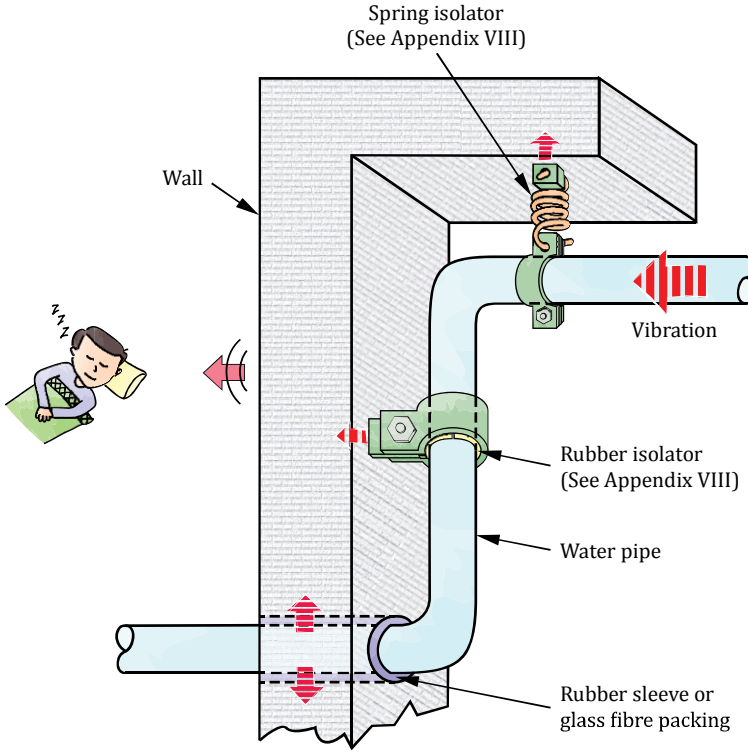


Figure 23 : Vibration Isolation of Pipes

(B)　實用矯正方法（續）

<u>經結構傳遞的噪音</u>

- 利用避震器繫喉管於牆壁、天花或地面（參考圖 23），使喉管與建築物結構隔離。
- 採用可壓縮物料分隔喉管與其穿透之地板和牆壁位置（參考圖 23），使喉管與建築物結構隔離。
- 安裝減壓閥以控制水壓及水流量，從而減低喉管的震動。

(噪音消減可達至 20 分貝(A))

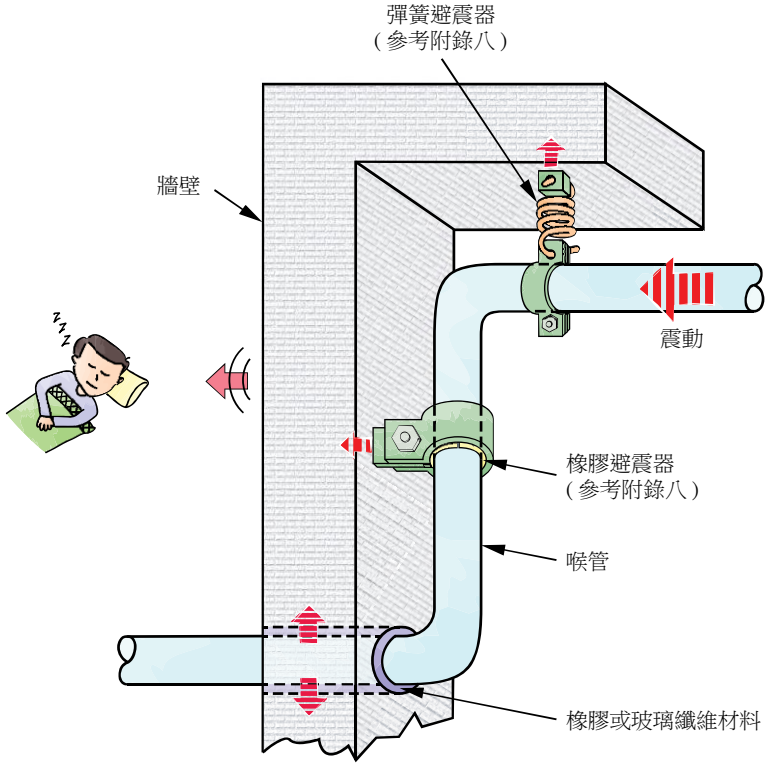


圖 23：　喉管的隔震

(B) Practical Remedies (Con't)

- Install pressure reducing valves to regulate water pressure and hence the water flow, thereby reducing vibration of pipes.

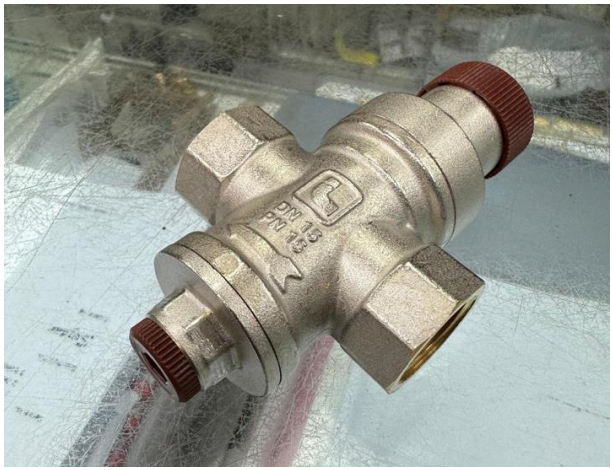


Figure 24 : Pressure Reducing Valve

(B)　實用矯正方法（續）

- 安裝減壓閥以控制水壓及水流量，從而減低喉管的震動。

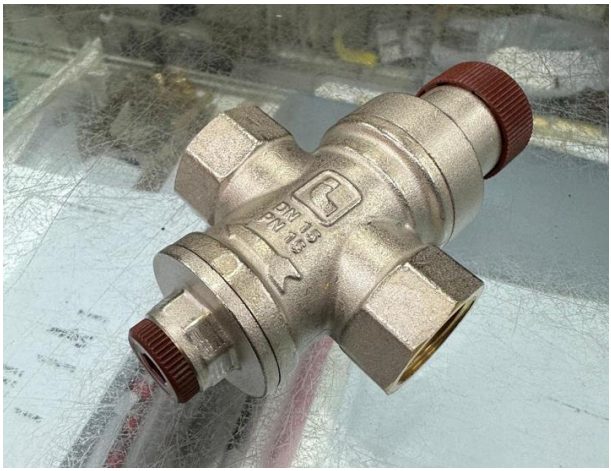


圖 24：　減壓閥

5.2.2. Pumpsets

(A) Noise Problems

Air-borne Noise

The major noise source of a pump is usually the bearing noise as a result of bearing worn-out. However, the noise contributed by the pump itself is small relative to that generated from its associated motor. The major noise source of a motor is usually the air movement induced by the cooling fan, which may cause noise disturbance to nearby residents (see Figure 25).

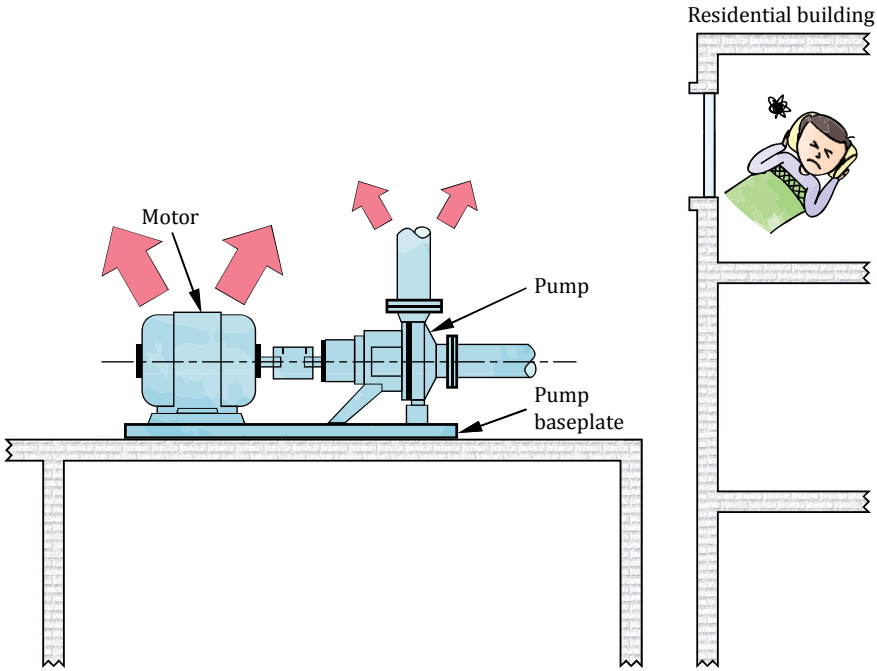


Figure 25 : Air-borne Noise from Pumpsets

5.2.2. 水泵組

(A) 噪音問題

經空氣傳遞的噪音

水泵發出的噪音主要來自磨損的軸承。但是水泵本身所發出的噪音通常少於其連接的馬達。馬達噪音主要由冷卻扇產生的大量空氣流動所引致，這些噪音可對近的居民造成噪音騷擾（參考圖 25）。

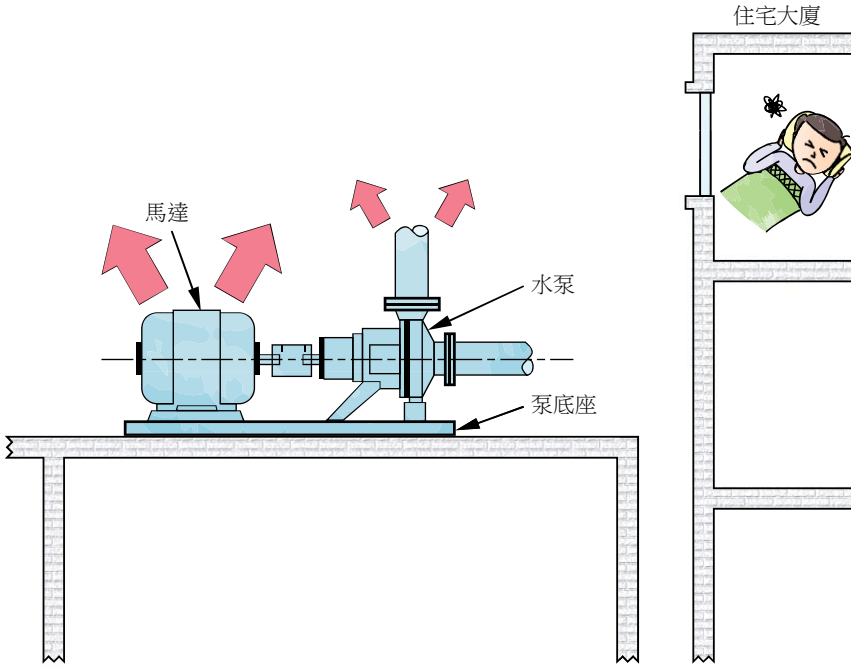


圖 25： 經空氣傳遞的水泵組噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from an operating pumpset may be transmitted to the interior of the building through building structure when the pumpset is directly mounted on a supporting structure without proper isolation (see Figure 26). The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building.

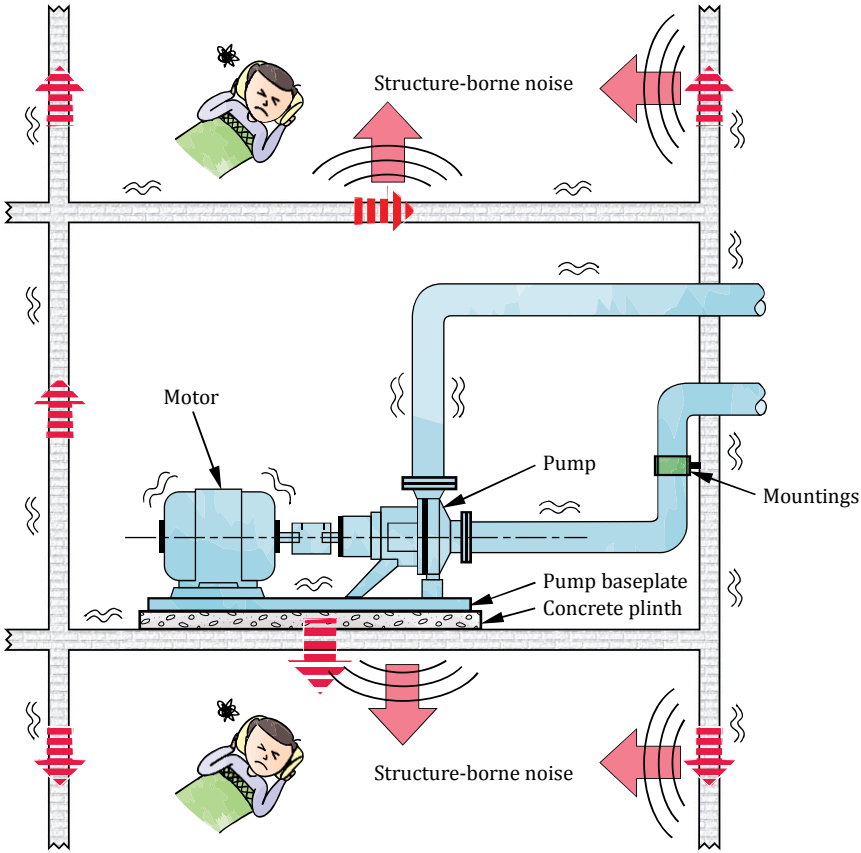


Figure 26 : Structure-borne Noise from Pumpsets

(A) 噪音問題（續）

經結構傳遞的噪音

假若水泵組直接裝置在承托的結構上而缺乏適當隔離，其產生的震動可通過建築物結構傳至室內（參考圖 26）。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民。

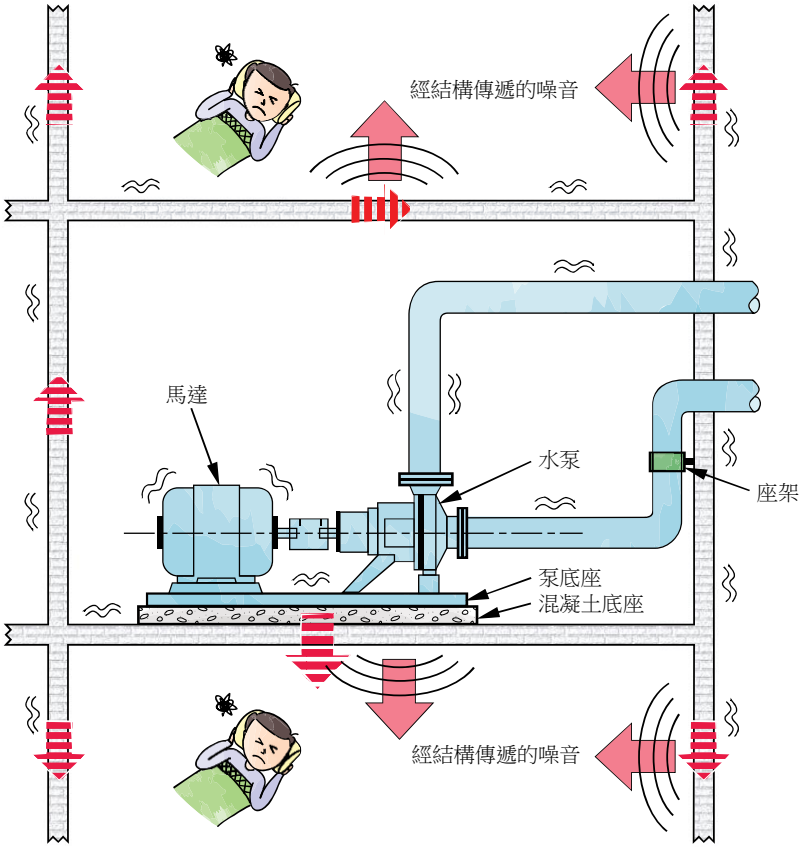


圖 26： 經結構傳遞的水泵組噪音

(B) Practical Remedies

Air-borne Noise

- Replace worn-out bearing so as to reduce the noise.
- Erect a barrier between the pumpset and nearby residential buildings (see Figure 27) so as to block the noise propagation path (see Appendix VI).
- Fabricate a partial enclosure to contain and absorb the noise energy radiated by the source (see Appendix V).

(Noise Reduction Up to 10 dB(A))

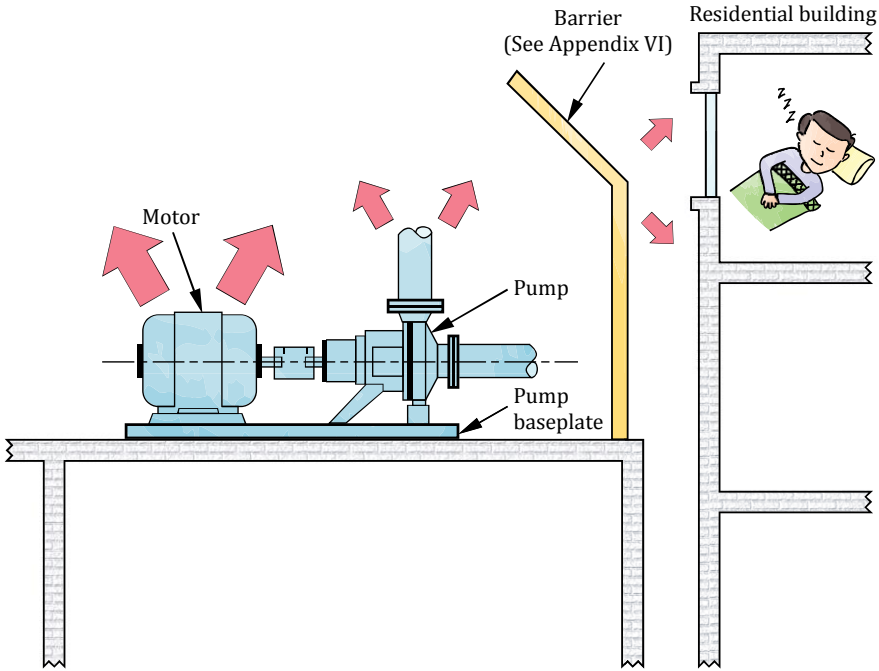


Figure 27 : Barrier for Pumpsets

(B)　實用矯正方法

<u>經空氣傳遞的噪音</u>

- 更換磨損的軸承以減低噪音。
- 在水泵組與附近住宅大廈之間加設隔音屏障（參考圖 27）以阻礙噪音之傳遞（參考附錄六）。
- 採用局部隔音罩以圍封及吸收從噪音源所發出之噪音（參考附錄五）。

(噪音消減可達至 10 分貝(A))

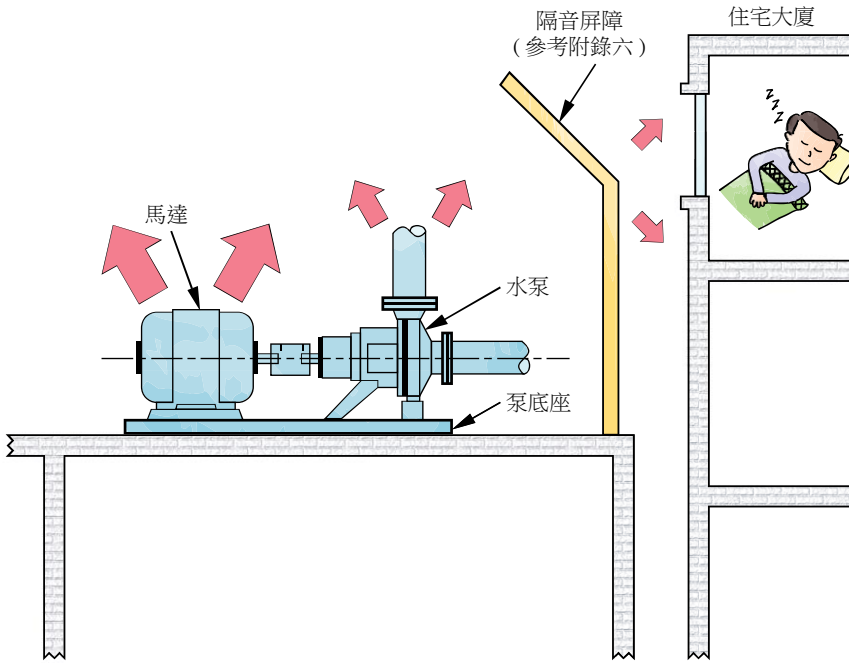


圖 27：　應用於水泵組的隔音屏障

(B) Practical Remedies (Con't)

- Fabricate a complete enclosure with silencers at inlet and outlet of the enclosure (see Figure 28) so as to contain and absorb the noise energy radiated by the source (see Appendix IV).

(Noise Reduction Up to 30 dB(A))

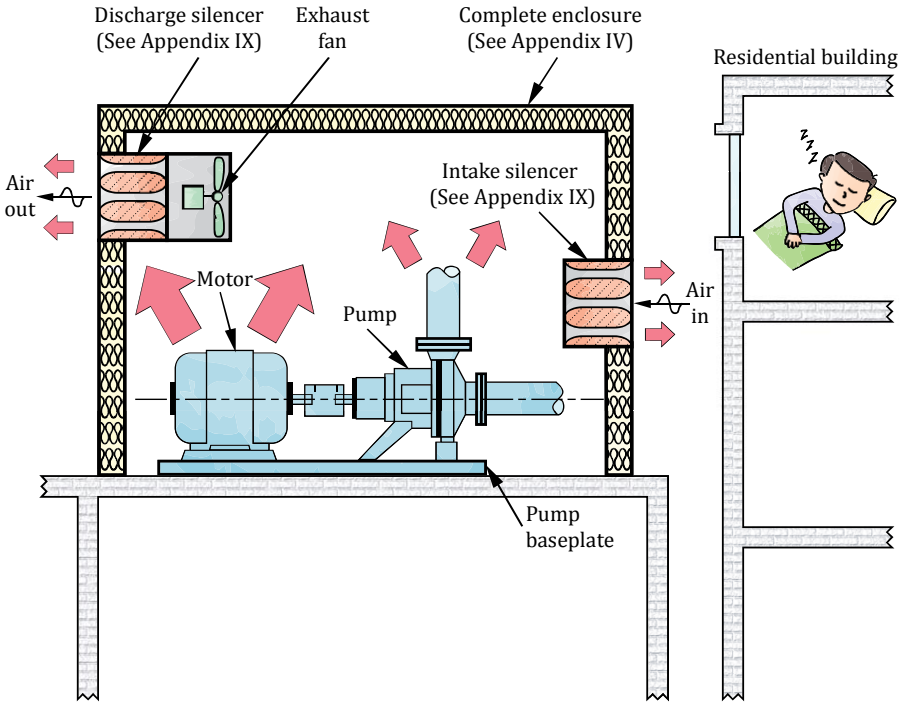


Figure 28 : Complete Enclosure for Pumpsets

(B)　實用矯正方法（續）

- 採用完全隔音罩附以進氣口及排氣口消聲器（參考圖 28）以圍封及吸收從噪音源所發出之噪音（參考附錄四）。

(噪音消減可達至 30 分貝(A))

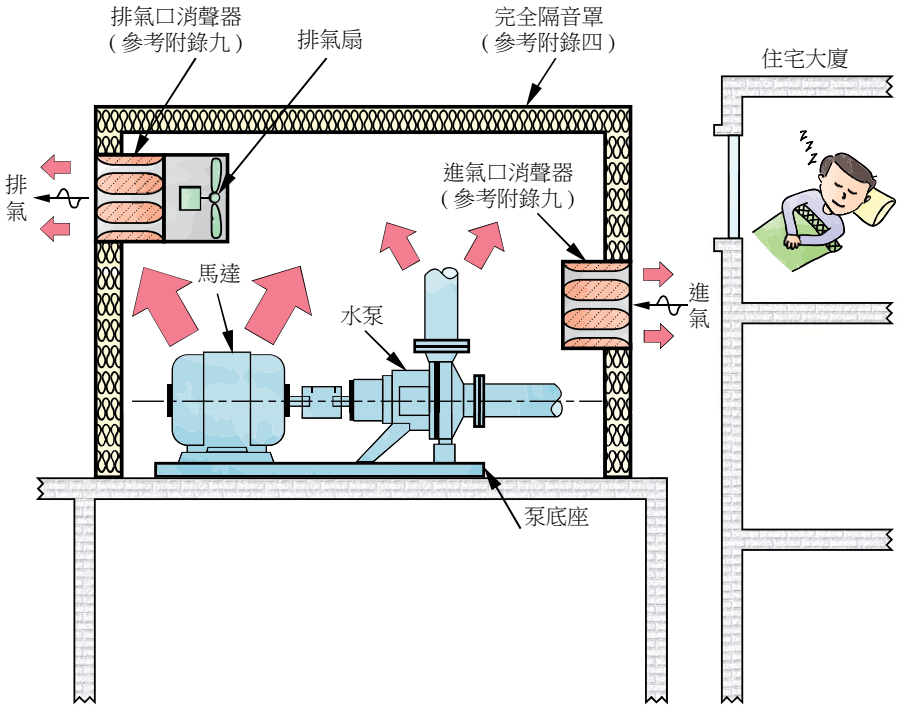


圖 28：　應用於水泵組的完全隔音罩

(B) Practical Remedies (Con't)

- Locate the pumpset inside a plantroom (see Figure 29) with silencers at air inlet and outlet, and a soundproof door (see Appendix XII).

(Noise Reduction Up to 30 dB(A))

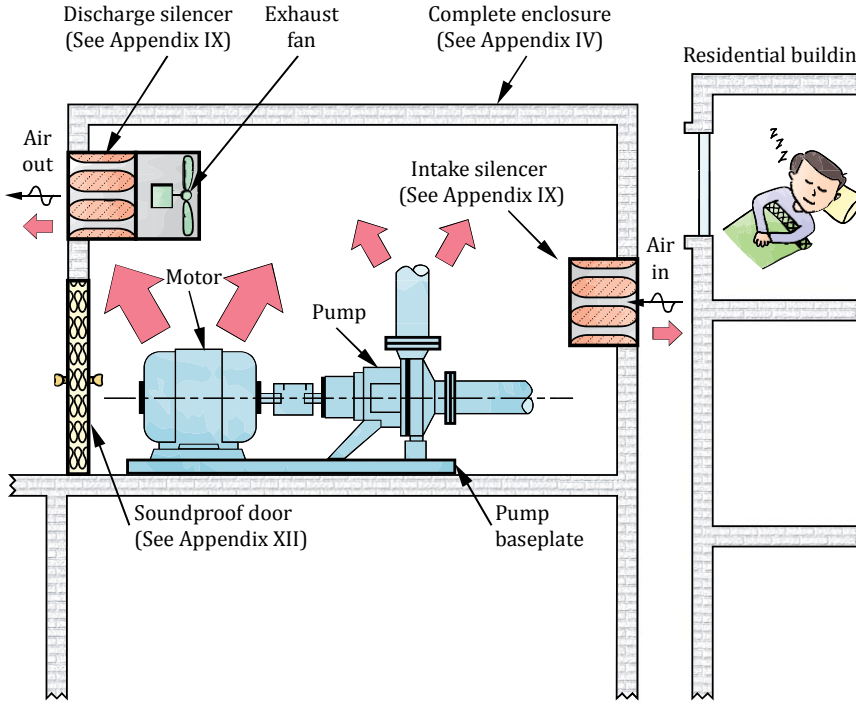


Figure 29 : Plantroom for Pumpsets

(B)　實用矯正方法（續）

- 將水泵組裝置在設有進氣口及排氣口消聲器及隔音門 (參考附錄十二) 的機房內 (參考圖 29) 。

(噪音消減可達至 30 分貝(A))

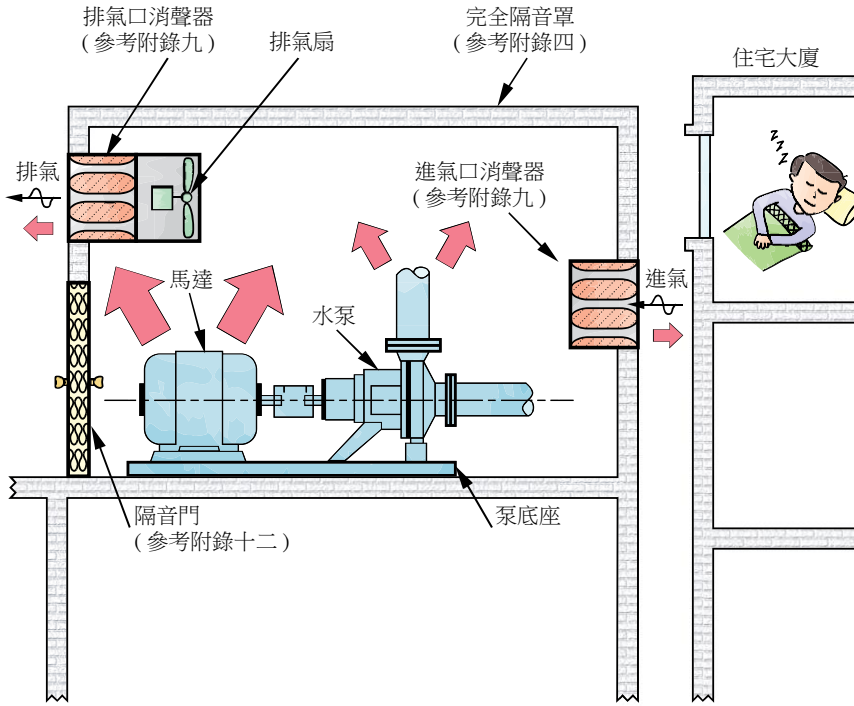


圖 29：　裝置於機房的水泵組

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide an inertia block to support the pumpset (see Figure 30) so as to add rigidity and stability to the pumping system, and provide vibration isolators (see Figure 30) to support the inertia block, thereby isolating it from the building structure (see Appendix VII and Appendix VIII).
- Provide flexible connectors between the pump and associated pipework, thereby preventing the vibration of the pumpset being transmitted to the pipework (see Figure 30).

(Noise Reduction Up to 20 dB(A))

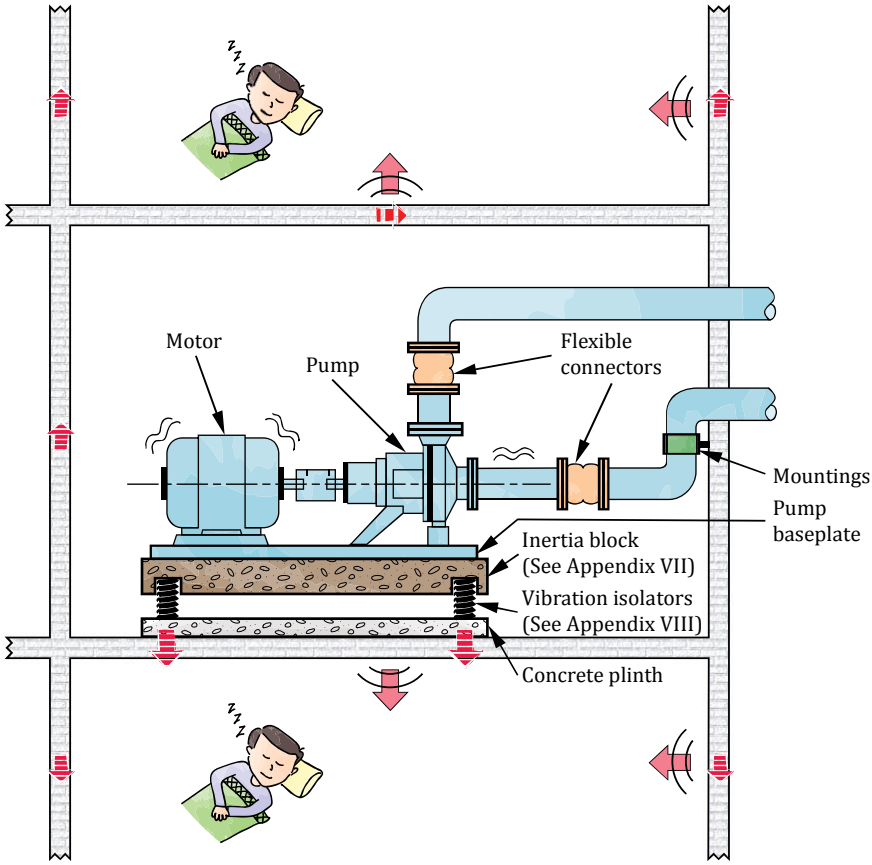


Figure 30 : Vibration Isolation for Pumpsets

(B)　實用矯正方法（續）

經結構傳遞的噪音

- 以浮動混凝土底座支撐水泵組（參考圖 30），從而增加整個系統的堅硬性和穩定性；及以避震器支撐浮動混凝土底座（參考圖 30）使其與建築物結構隔離（參考附錄七及八）。
- 利用彈性接口連接水泵及其喉管組以避免水泵組的震動傳至喉管組（參考圖 30）。

(噪音消減可達至 20 分貝(A))

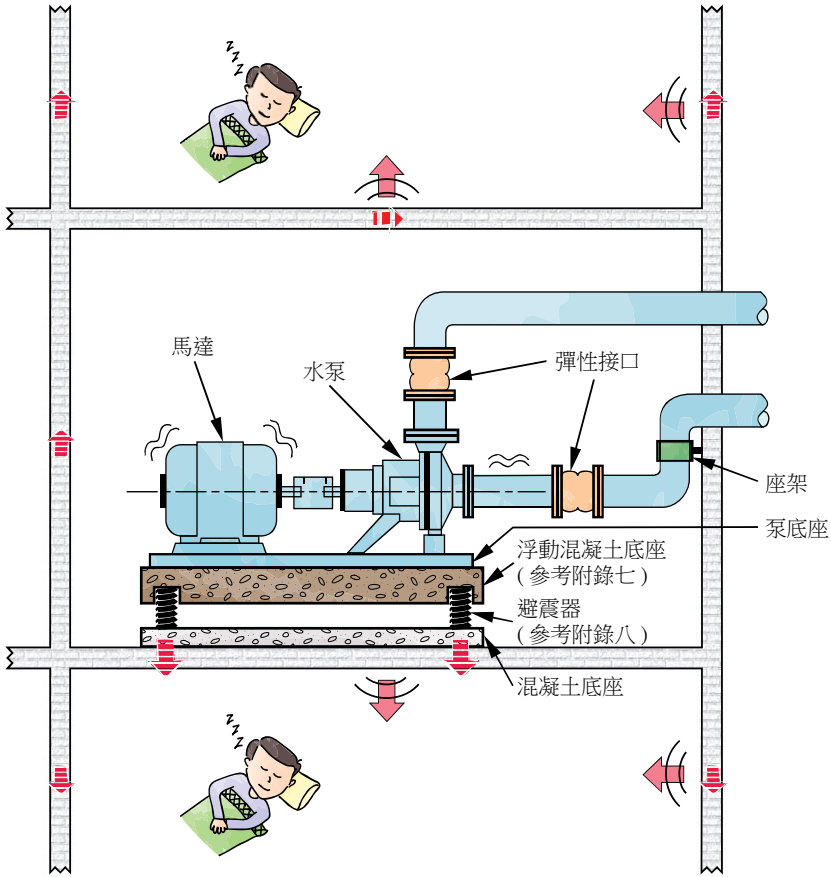


圖 30：　水泵組的隔震

5.3. Lift Systems

5.3.1. Traction Machines

(A) Noise Problems

Air-borne Noise

Noise generated from the traction machine may cause noise disturbance to nearby residents. It mainly comes from the noise from motors, mechanical noise of geared systems, and noise from brakes.

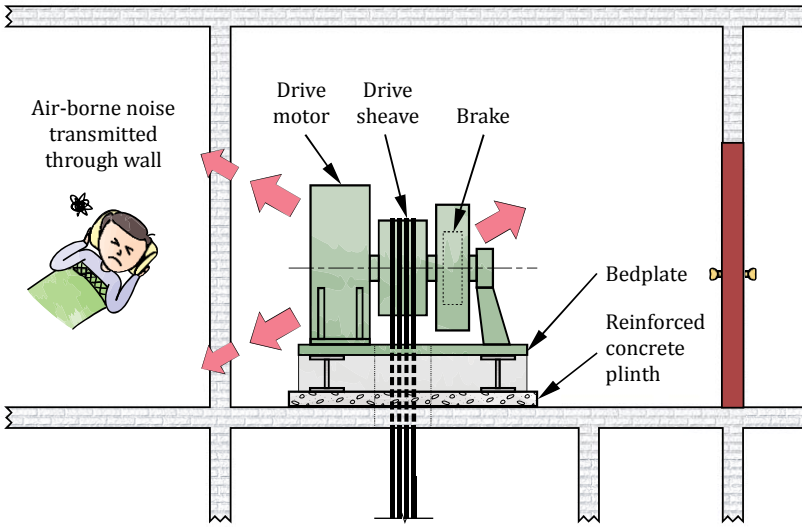


Figure 31 : Air-borne Noise from Traction Machines

5.3. 升降機系統

5.3.1. 曳引機械

(A) 噪音問題

經空氣傳遞的噪音

升降機系統的曳引機械可對其附近居民造成噪音騷擾，其噪音主要來自馬達噪音、齒輪系統的機械噪音及制動器運作時發生的噪音。

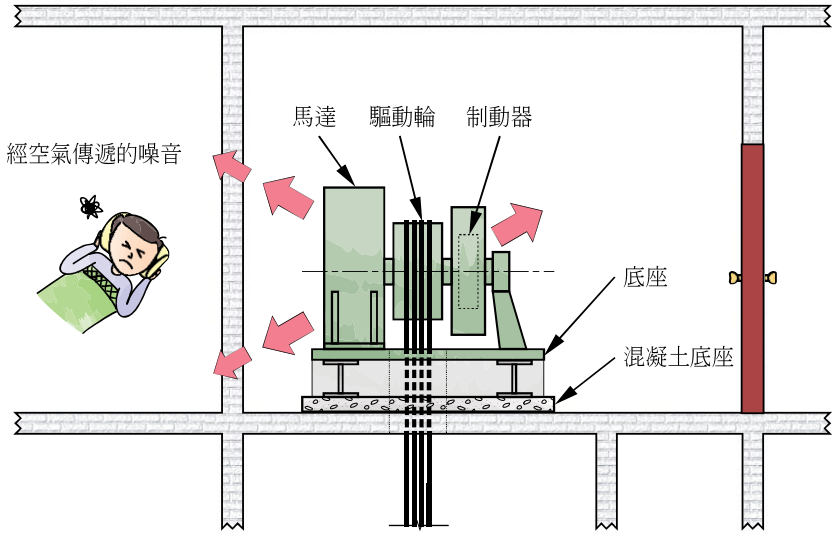


圖31： 經空氣傳遞的曳引機械噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from the vibration impact of the traction machine may be transmitted through building structure at points where the machine is rigidly fixed to the structure without proper isolation. The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents nearby (see Figure 32).

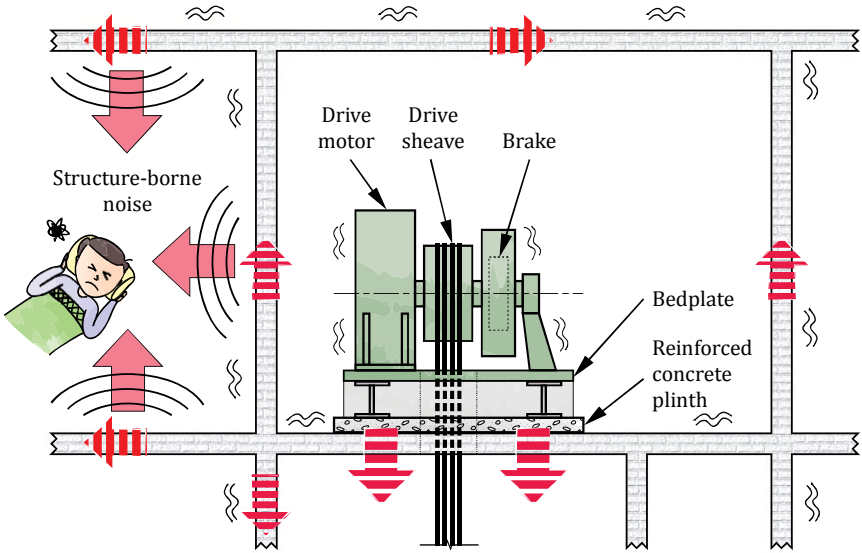


Figure 32 : Structure-borne Noise from Traction Machines

(A) 噪音問題（續）

經結構傳遞的噪音

如曳引機械直接固定在建築結構上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民（參考圖 32）。

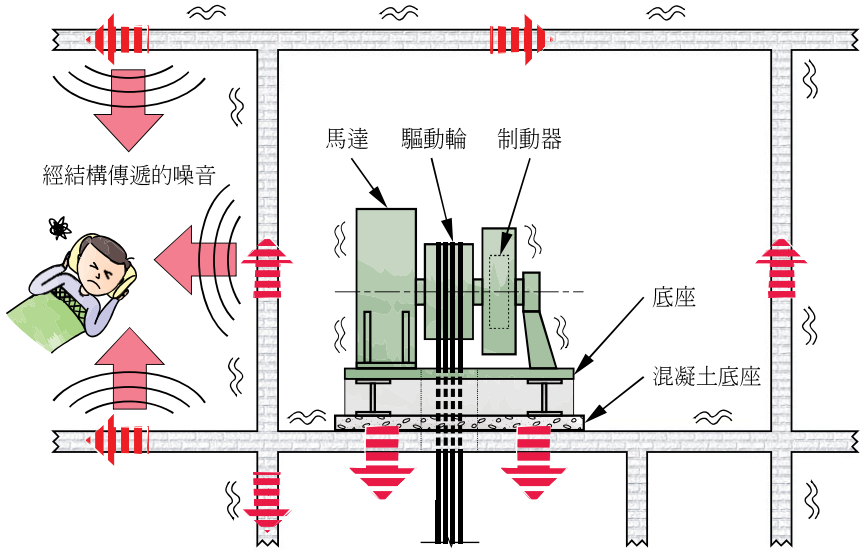


圖 32： 經結構傳遞的曳引機械噪音

(B) Practical Remedies

Air-borne Noise

- Provide thick walls, sound absorptive materials and soundproof door to plant room for traction machines (see Figure 33).
- Install silencers to air inlets and outlets (see Appendix IX).

(Noise Reduction Up to 10 dB(A))

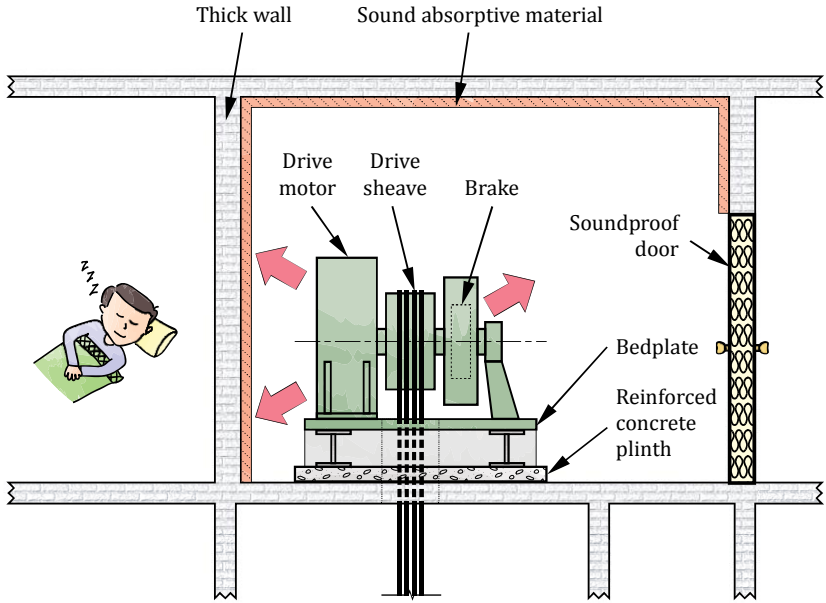


Figure 33 : Noise Absorption and Insulation in Plantroom for Traction Machines

(B)　實用矯正方法

經空氣傳遞的噪音

- 為升降機機房設置厚牆壁、鋪設吸音物料、安裝隔音門 (參考圖 33)。
- 安裝消聲器於進氣口及排氣口（參考附錄九）。

(噪音消減可達至 10 分貝(A))

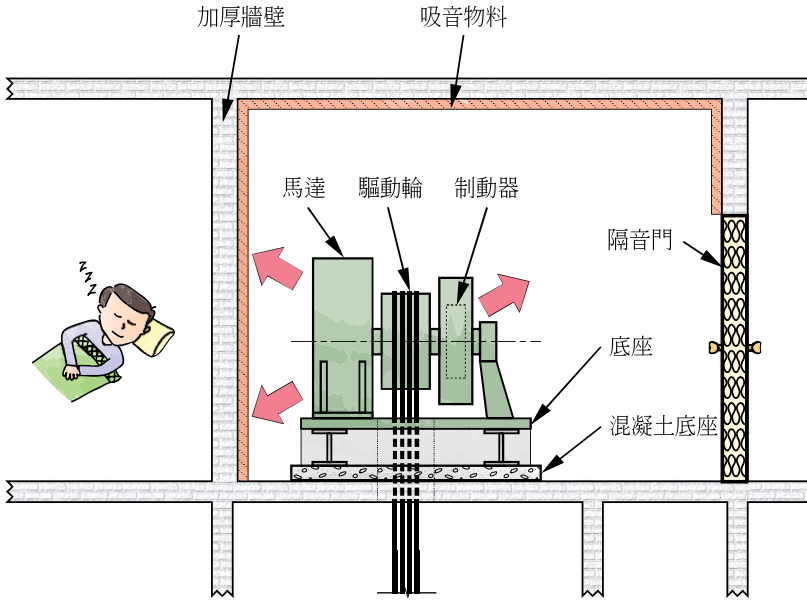


圖 33：　曳引機械機房的吸音及隔音

(B) Practical Remedies (Con't)

Structure-borne Noise

- Use anti-vibration pad or vibration isolator (see Figure 34, Figure 35 and Appendix VIII) and floating floor (see Appendix X) between the vibrating machines and the fixed building structure to avoid structural vibration transmission.
- Provide an inertia block with vibration isolators to support the vibration machines.

(Noise Reduction Up to 20 dB(A))

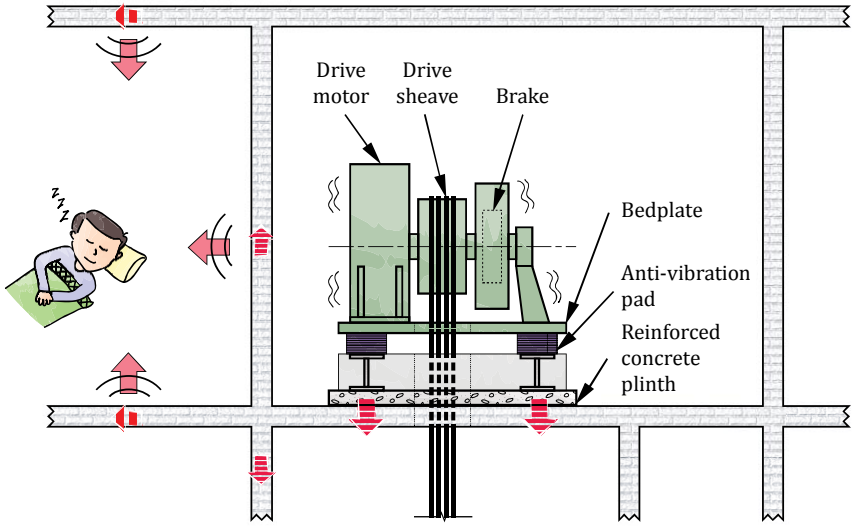


Figure 34 : Vibration Isolation for Traction Machines

Figure 35 : Anti-vibration pad for Traction Machines

(B)　實用矯正方法（續）

<u>經結構傳遞的噪音</u>

- 為曳引機械安裝避震軟墊或避震器(參考圖 34、圖 35 及附錄八)及浮動地台（參考附錄十），可避免震動通過建築物結構傳至室內。
- 利用設有避震器的浮動混凝土底座支撐曳引機械。

(噪音消減可達至 20 分貝(A))

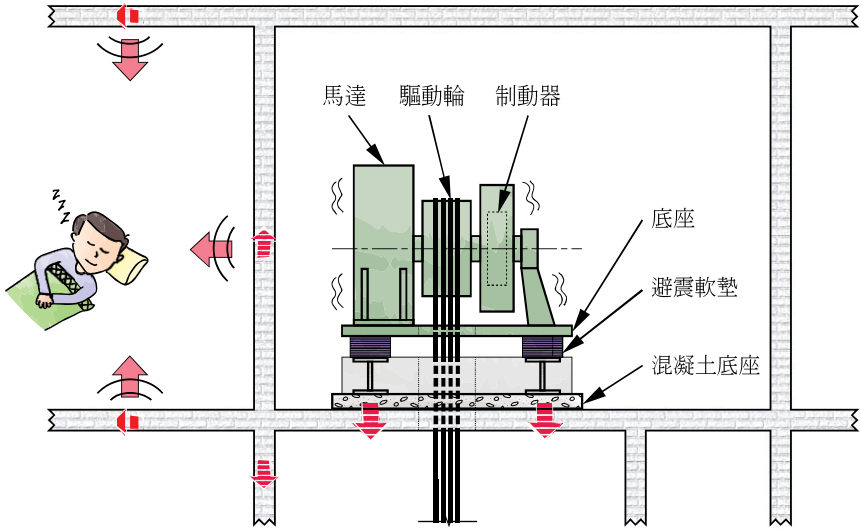


圖 34：　曳引機械的隔震

圖 35：　用於曳引機械的避震軟墊

5.3.2. Guide Rails

(A) Noise Problems

Structure-borne Noise

Vibration from the vibration impact from the rolling or sliding between the lift guide shoes and guide rails may be transmitted through lift shaft wall which is part of the building structure. The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents nearby (see Figure 36).

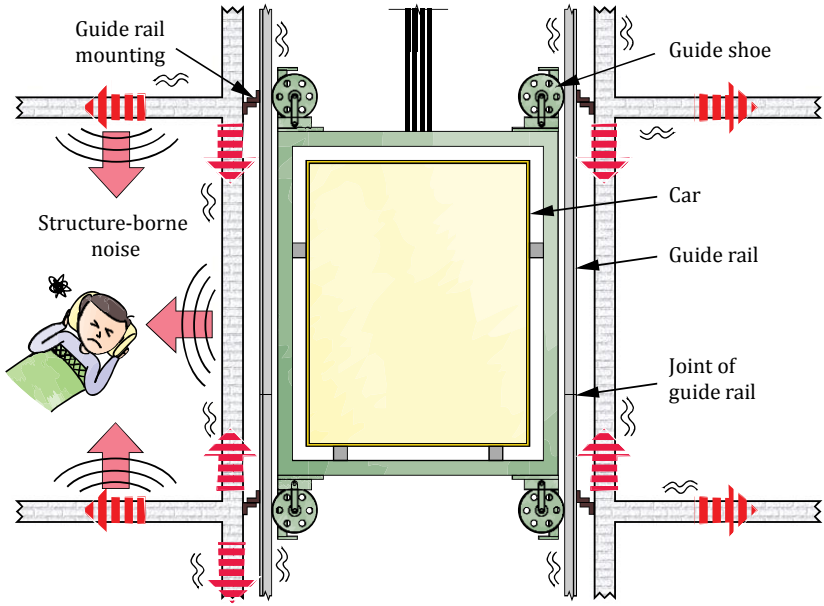


Figure 36 : Structure-borne Noise from Guide Rails

5.3.2. 導軌

(A) **噪音問題**

經結構傳遞的噪音

導軌與導靴之間的滾動或滑動接觸而產生的震動可經井道牆壁及其他建築物結構傳至室內，這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民（參考圖 36 ）。

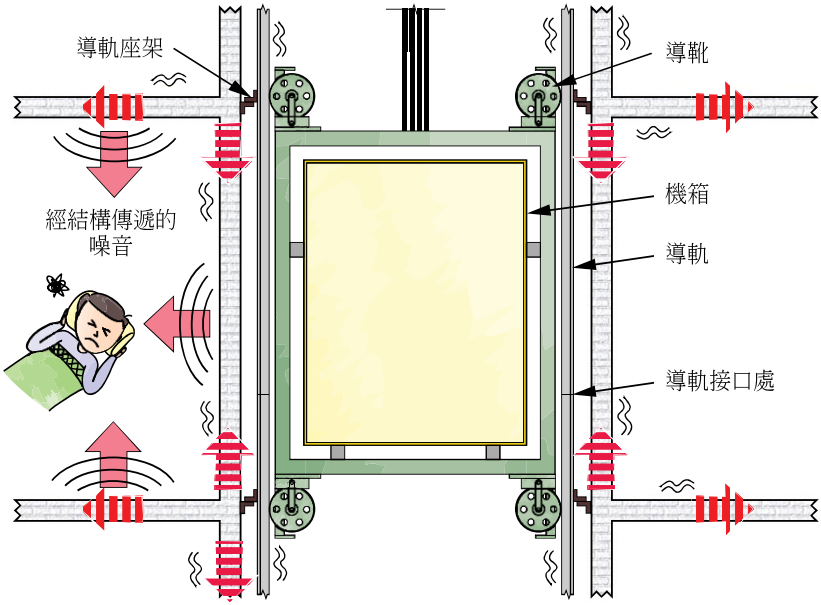


圖 36： 經結構傳遞的導軌噪音

(B) Practical Remedies

Structure-borne Noise

- Provide vibration isolation pads for the guide rail (see Figure 37 and Figure 38). This involves operational safety of the lift, lift supplier should be consulted.

(Noise Reduction Up to 20 dB(A))

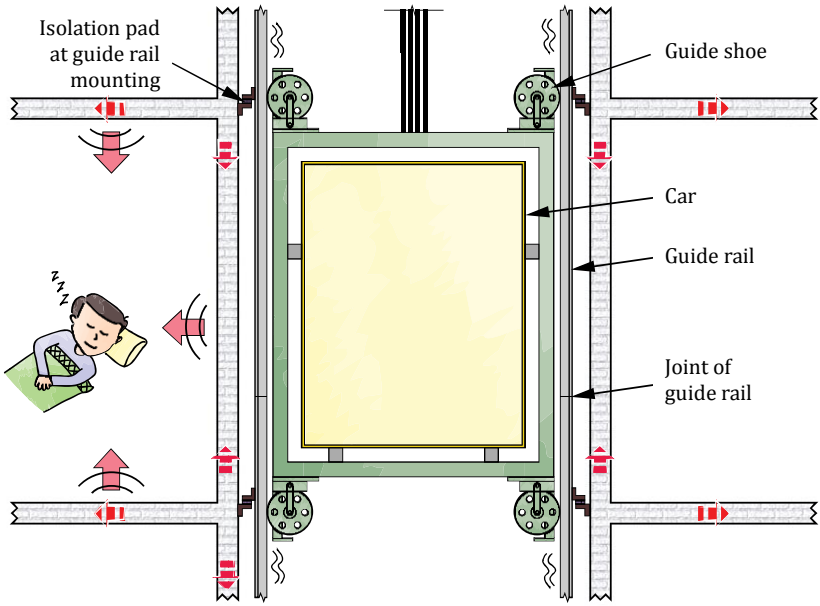
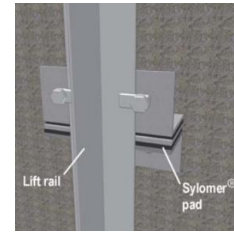


Figure 37 : Vibration Isolation of Guide Rails

(Image Courtesy of CDM Stravitec)



(Image Courtesy of Mason Industries)

Figure 38 : Vibration Isolation Pads for Guide Rails

(B)　實用矯正方法

<u>經結構傳遞的噪音</u>

- 於導軌上與井道牆壁之間裝置避震軟墊 (參考圖 37 及
- 圖 *38*) 。此牽涉升降機運作上的安全問題，如在導軌上加裝避震軟墊前應徵詢升降機供應商的專業意見。

(噪音消減可達至 20 分貝(A))

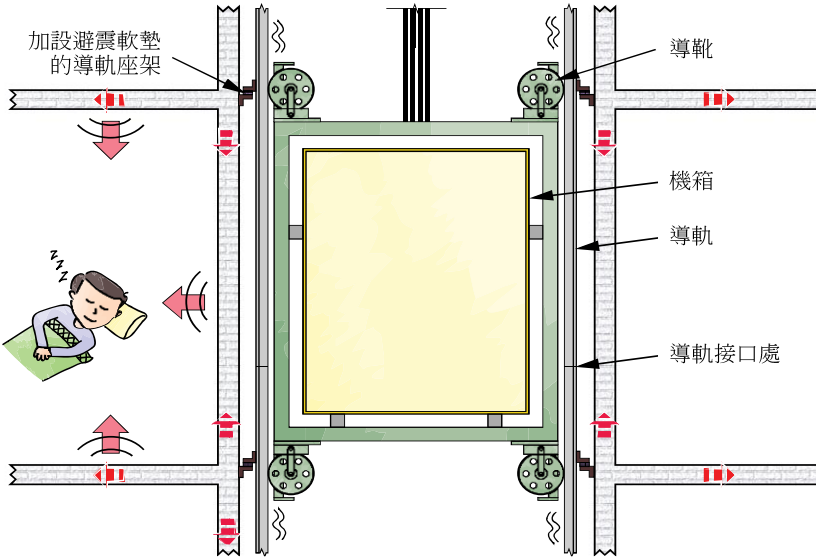
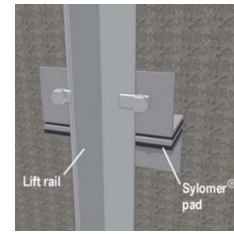


圖 37：　升降機導軌的隔震

（蒙 CDM Stravitec
特許轉載此圖）



（蒙梅森實業有限公司
特許轉載此圖）

圖 38：　用於電梯導軌的避震軟墊

5.3.3. Hydraulic Lifts

(A) Noise Problems

Air-borne Noise

Noise generated from the hydraulic lifts may cause noise disturbance to nearby residents. It mainly comes from the noise from the power unit, motor, pump and valves (see Figure 39).

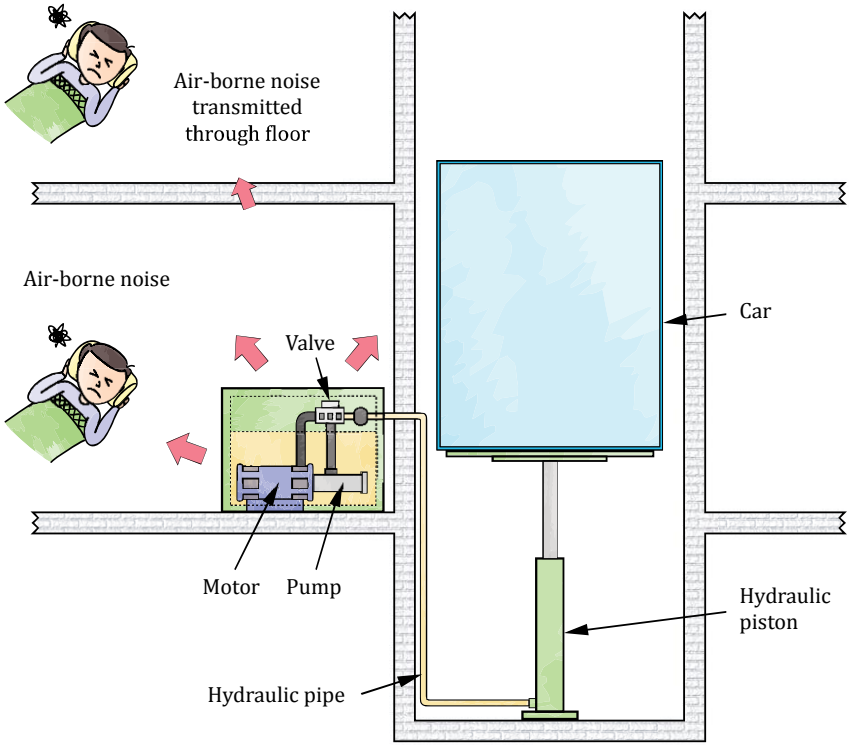


Figure 39 : Air-borne Noise from Hydraulic Lifts

5.3.3. 油壓升降機

(A) 噪音問題

經空氣傳遞的噪音

油壓升降機可對其附近居民造成噪音騷擾，其噪音主要來自電源設備、馬達、油壓泵及控制閥 (參考圖 39)。

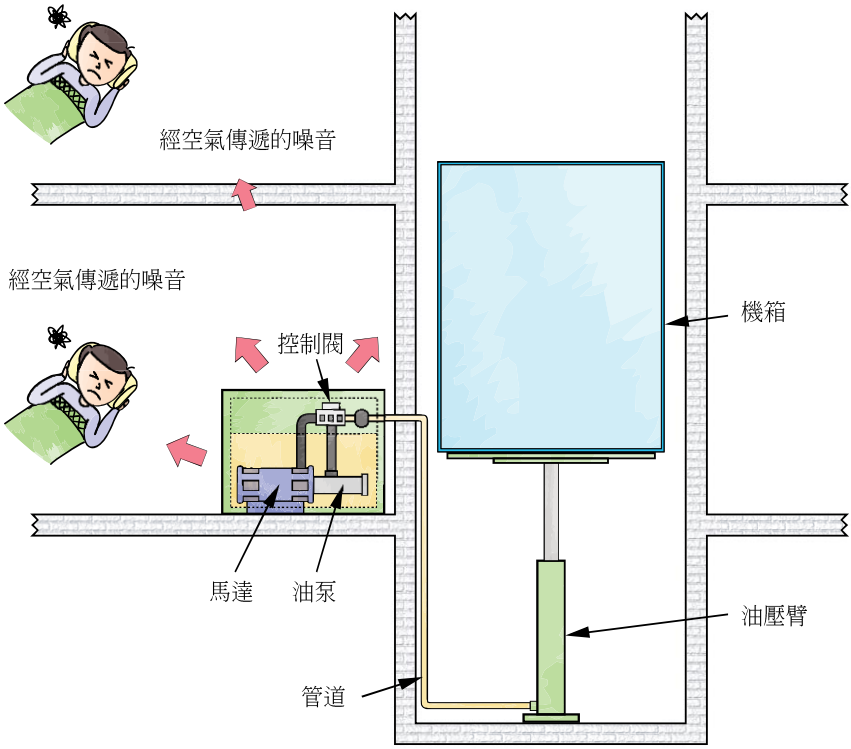


圖 39： 經空氣傳遞的油壓升降機噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from the vibration impact of the hydraulic lifts may be transmitted through building structure at points where the machine is rigidly fixed to the structure without proper isolation. The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents nearby (see Figure 40).

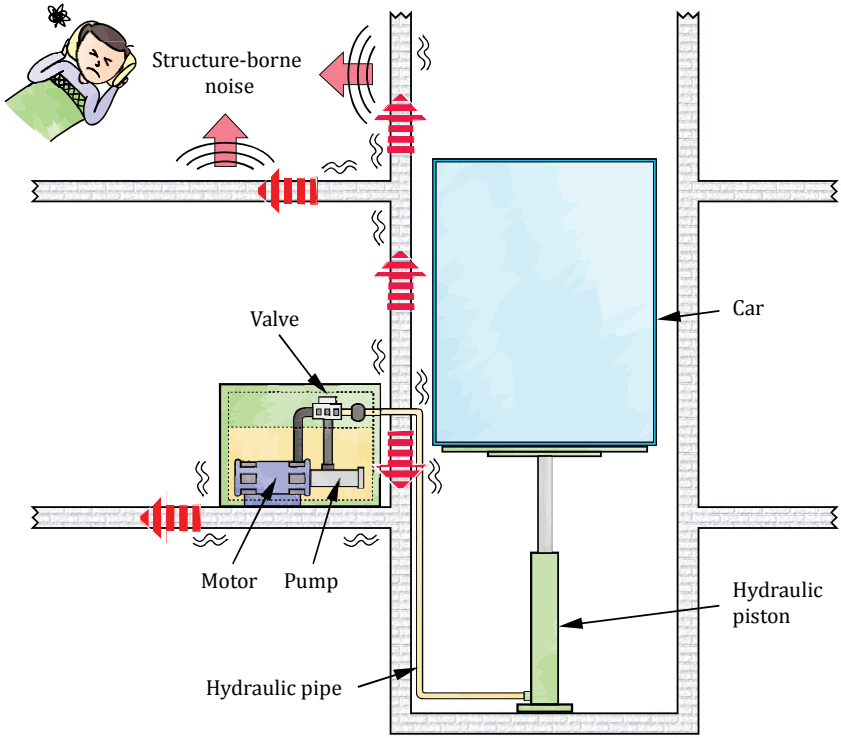


Figure 40 : Structure-borne Noise from Hydraulic Lifts

(A) 噪音問題（續）

經結構傳遞的噪音

如油壓升降機固定在建築物結構上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民 (參考圖 40)。

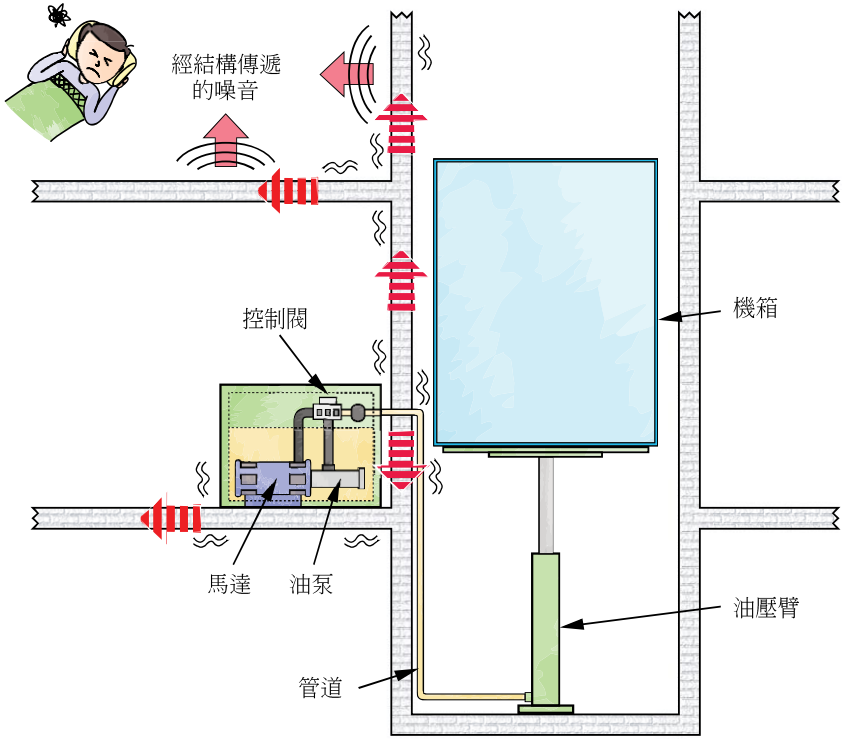


圖 40： 經結構傳遞的油壓升降機噪音

(B) Practical Remedies

Air-borne Noise

- Provide plant room with sound absorptive material for the power unit, motor and pump of a hydraulic lift (see Figure 41).

(Noise Reduction Up to 5 dB(A))

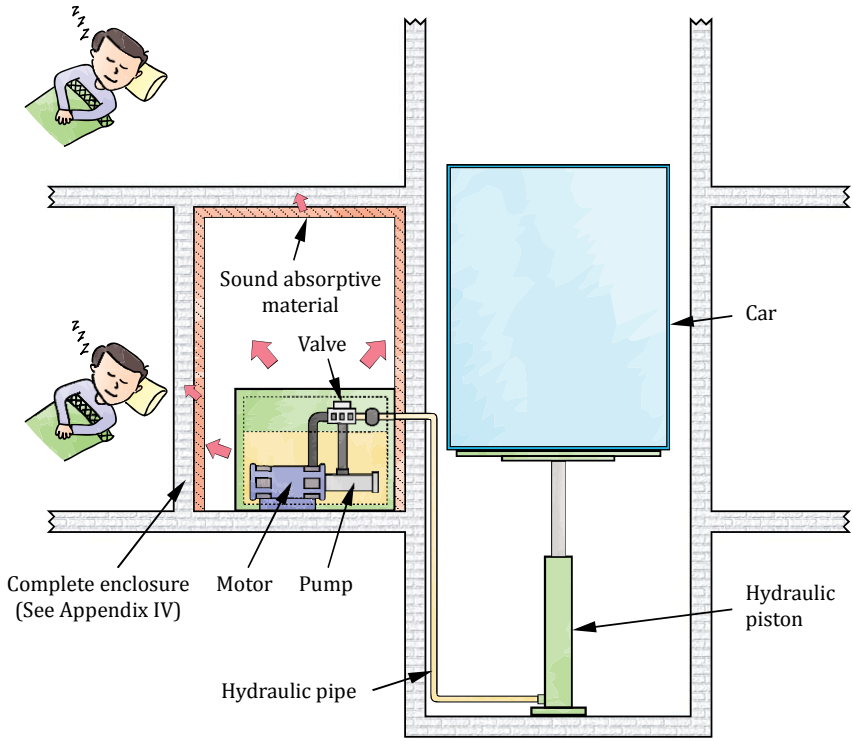


Figure 41 : Plant Room for Power Units of Hydraulic Lifts

(B)　實用矯正方法

經空氣傳遞的噪音

- 設置油壓升降機的電源設備、馬達及油壓泵於鋪上吸音物料的機房內，以阻礙噪音之傳遞 (參考圖 41) 。

（噪音消減可達至 5 分貝(A)）

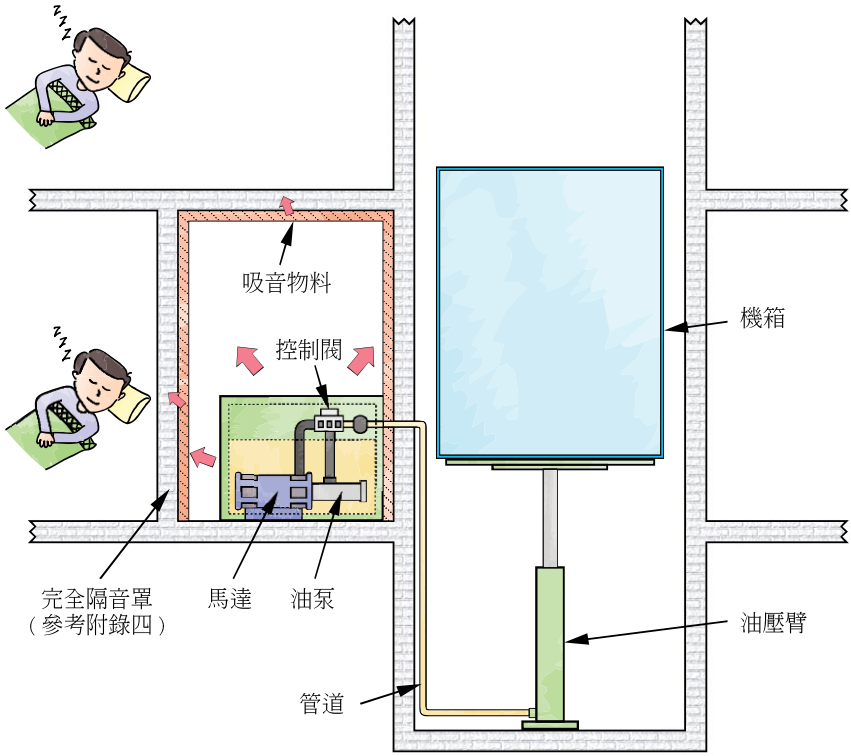


圖 41：　裝置於機房的油壓升降機設備

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide inertia block and vibration isolators for the power unit and pump of the hydraulic lift (see Figure 42, Appendix VII and Appendix VIII).

(Noise Reduction Up to 20 dB(A))

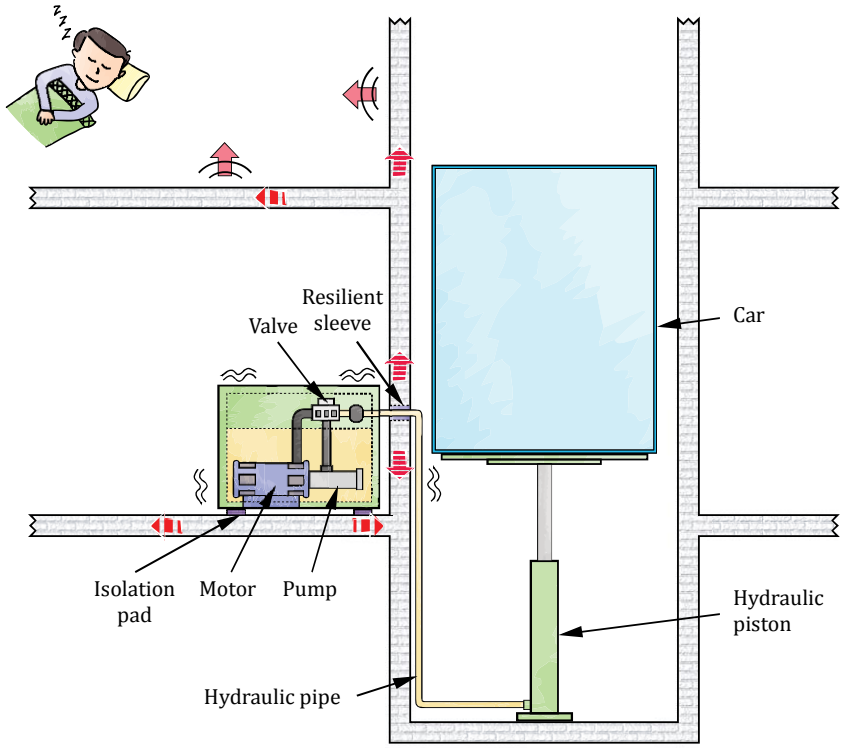


Figure 42 : Vibration Isolation for Hydraulic Lifts

(B)　實用矯正方法（續）

<u>經結構傳遞的噪音</u>

- 裝置避震器及浮動混凝土底座承托油壓升降機的電源設備、馬達及油壓泵，從而將設備與建築物結構隔離 (參考圖 42、附錄七及附錄八)。

（噪音消減可達至 20 分貝(A)）

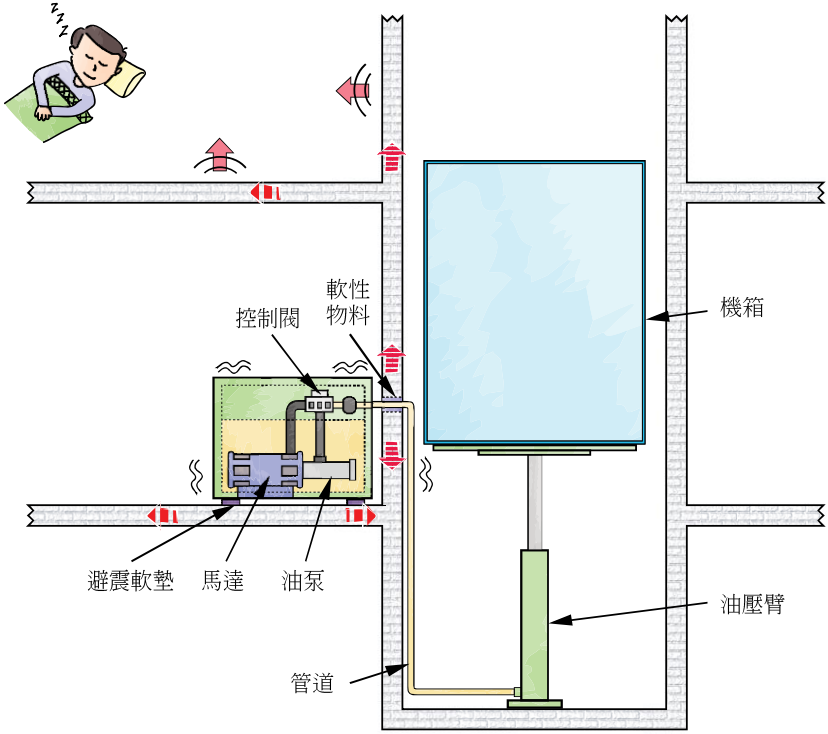


圖 42：　油壓升降機的隔震

5.4. Emergency Generator Sets

5.4.1. Emergency Generator Sets

(A) Problems

Air-borne Noise

Noise generated from emergency generator sets may cause disturbance to nearby residents. It mainly comes from the air flow noise resulting from air turbulence at the air intake and exhaust, compressor noise of turbocharger, combustion noise of internal combustion engine, fan noise and mechanical noise from engine and generator (see *Figure 43*).

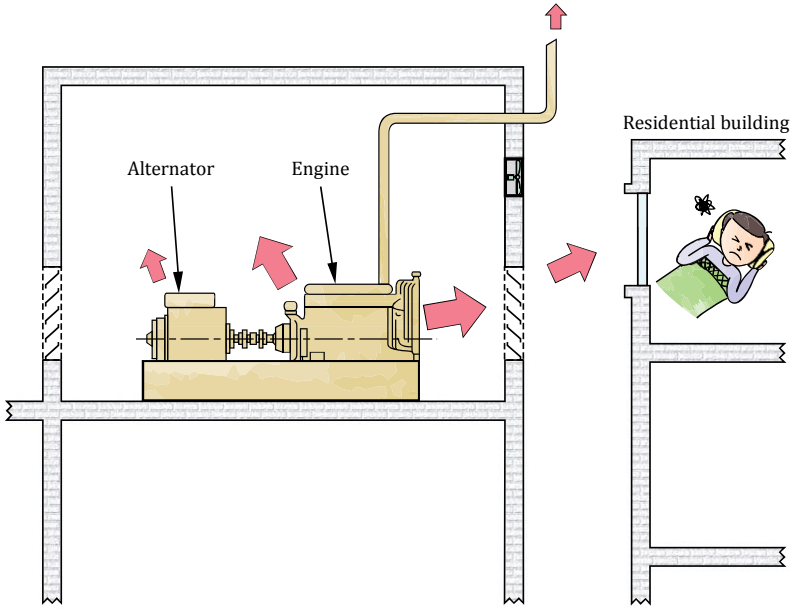


Figure 43 : Air-borne Noise from Emergency Generator Sets

5.4. 緊急發電機

5.4.1. 緊急發電機噪音

(A) 噪音問題

經空氣傳遞的噪音

緊急發電機運行時的噪音可對其附近的居民造成噪音騷擾，其噪音主要來自進氣口及排氣的湍流所產生的空氣流動噪音、渦輪增壓器的噪音、內燃式引擎的噪音、風扇噪音、及引擎與發電機的機械噪音 (參考圖 43) 。

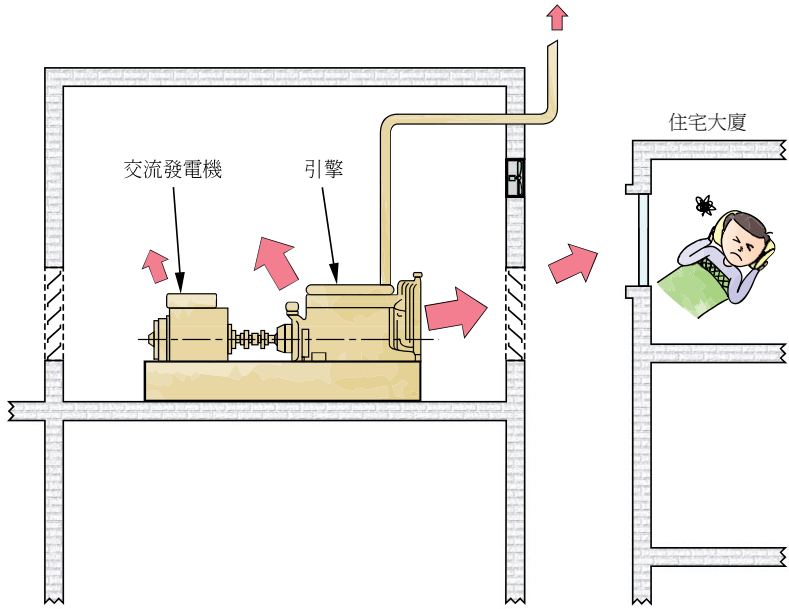


圖 43： 經空氣傳遞的緊急發電機噪音

(A) Noise Problems (Con't)

Structure-borne Noise

Vibration from an operating generator set may be transmitted to the interior of the building through building structure when the generator set is directly mounted on a supporting structure without proper isolation. The vibration transmitted may activate the building structure to generate noise which causes noise disturbance to residents inside the building (see Figure 44).

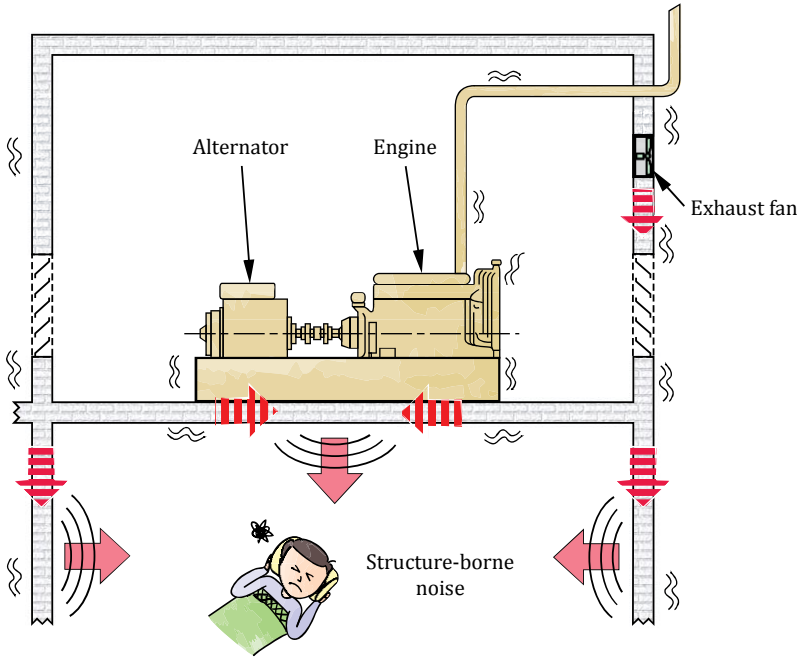


Figure 44 : Structure-borne Noise from Emergency Generator Sets

(A) 噪音問題（續）

經結構傳遞的噪音

如緊急發電機固定在建築物結構上而沒有適當隔離，其運行時所產生的震動可經建築物結構傳至室內。這些震動可觸發建築物結構發出噪音而騷擾到大廈內的居民 (參考圖 44) 。

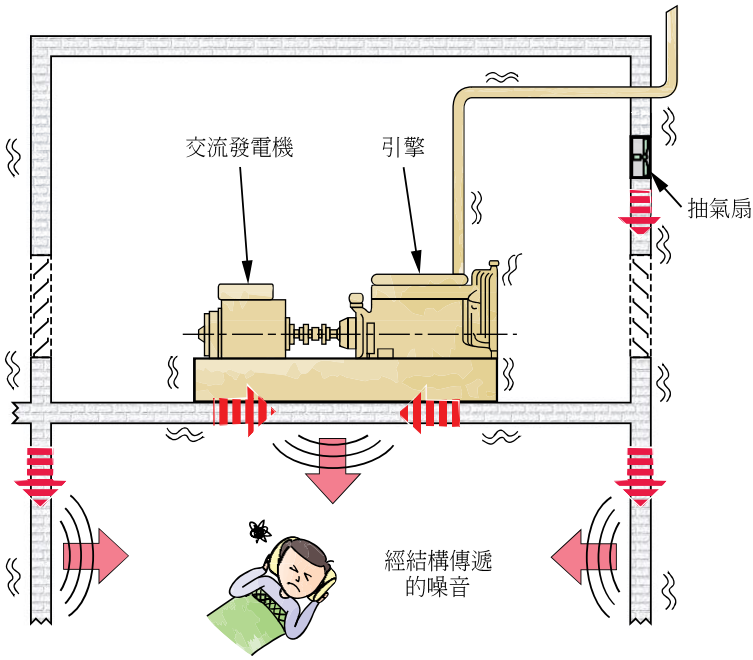


圖 44： 經結構傳遞的緊急發電機噪音

(B) Practical Remedies

Air-borne Noise

- Locate the emergency generator sets inside a plantroom (see *Figure 45* and Figure 46) with thick walls, sound absorption materials, soundproof door and silencers at air inlet and outlet.

(Noise Reduction Up to 30 dB(A))

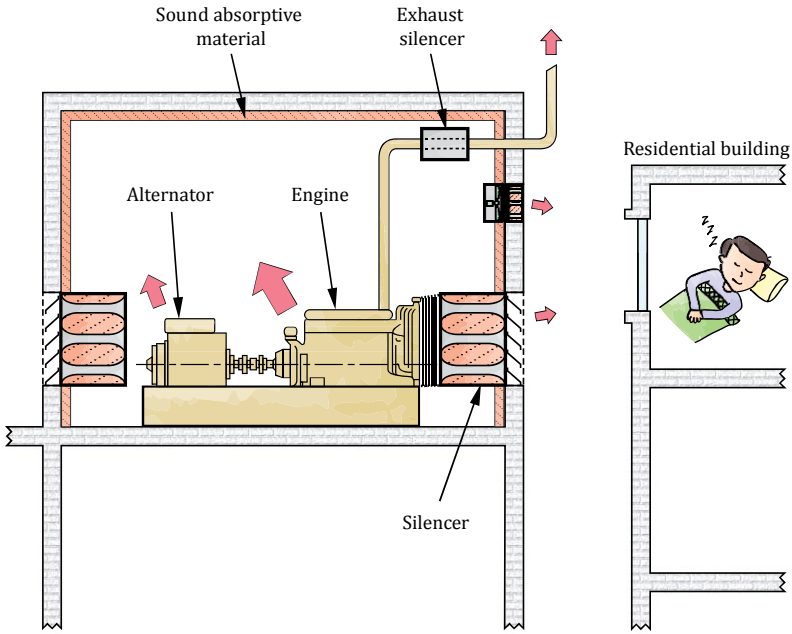


Figure 45 : Noise Insulation of Emergency Generator Set Plant Rooms

Sound insulation layer on walls

Soundproof door

Silencers at air inlet and outlet

Figure 46 : Plantroom for Emergency Generator Sets

(B)　實用矯正方法

經空氣傳遞的噪音

- 安置緊急發電機於設有厚牆、鋪設有吸音物料、設有進氣口及排氣口消聲器及隔音門的機房內 (*參考圖 45* 及圖 46)。

（噪音消減可達至 30 分貝(A)）

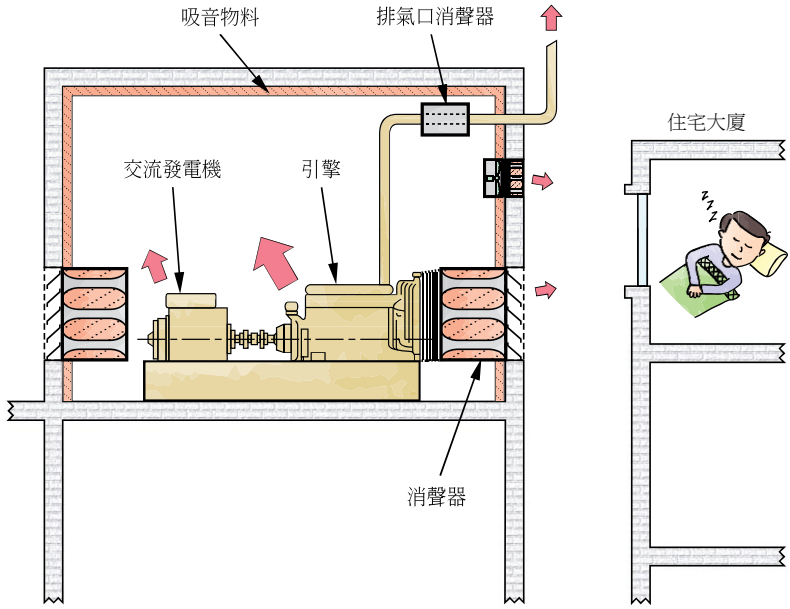


圖 45：　緊急發電機機房的隔聲

鋪設有吸音物料的牆壁

隔音門

進氣口及排氣口消聲器

圖 46：　裝置於機房的緊急發電機

(B) Practical Remedies (Con't)

Structure-borne Noise

- Provide inertia blocks and vibration isolators to support an emergency generator set (see Figure 47), thereby isolating from the building structure (see Appendix VIII).
- Provide flexible connectors between the machine and associated pipework to avoid structural vibration transmission (see Figure 47).
- Use vibration isolators for attaching pipes to walls, ceilings or floors (see Appendix VIII).

(Noise Reduction Up to 20 dB(A))

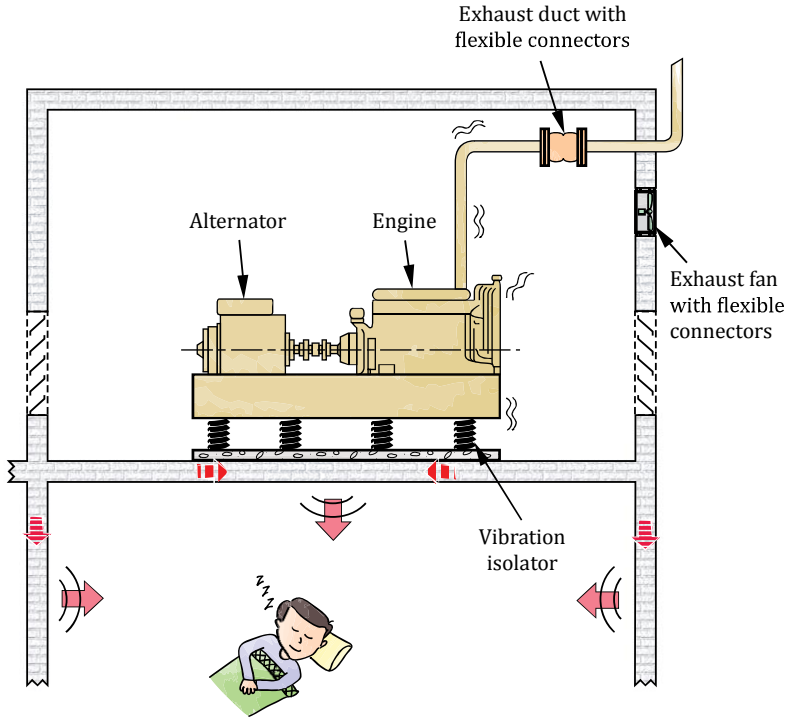


Figure 47 : Vibration Isolation for Emergency Generators

(B)　實用矯正方法（續）

經結構傳遞的噪音

- 利用浮動混凝土底座和避震器將緊急發電機(參考*圖 47*) 與建築物結構隔離 (參考附錄八) 。
- 利用彈性接口連接緊急發電機及其喉管，可避免發電機的震動通過建築物結構傳至室內 (*參考圖47*)。
- 利用避震器將喉管固定於牆壁、天花或地面上 (參考附錄八)。

(噪音消減可達至 20 分貝(A))

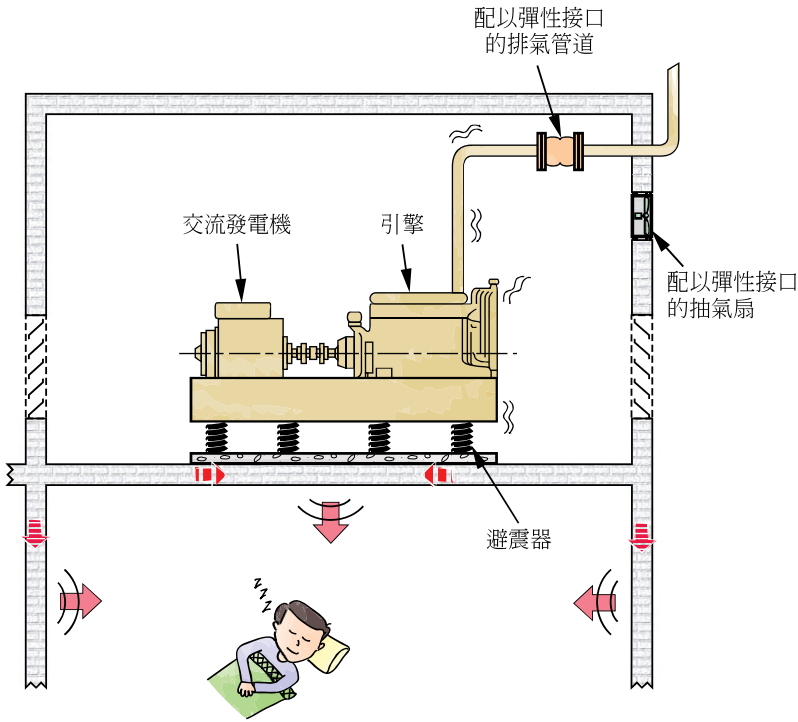


圖 47：　緊急發電機的隔震

5.5. Defective Implementation of Noise Mitigation Measures

5.5.1. Noise Leakage through Noise Barriers or Enclosures

The presence of holes, slits, cracks or gaps through noise barriers and enclosures can reduce the noise isolation performance significantly. The problem is rectified by sealing up of the gaps.

5.5.2. Short-circuited Vibration Isolators

Short-circuiting of vibration isolators greatly affects the vibration isolation and thus the structure-borne noise reduction performance. An example of defective implementation of vibration isolators is shown in Figure 48. The metal spring had been tightened up by building management due to a lack of understanding of the vibration isolation mechanism, leaving no clearance for the functioning of the vibration isolator, causing excessive transmission of structure-borne vibration to the receiver within the building. The problem is rectified by reinstating the initial setting of the metal spring, leaving the metal spring to vibration freely to achieve the desired vibration isolating performance.

Defective implementation of a vibration isolator

Normal implementation of a vibration isolator

Figure 48 : An Example of Defective Implementation of Vibration Isolators

5.5. 噪音緩解措施的不妥善安裝

5.5.1. 隔音屏障或隔音罩的漏聲

隔音屏障或隔音罩上的間隙或接口可引致噪音滲漏，影響了噪音緩解措施的隔音效果。可滲漏噪音的間隙及接口應以適當填封物封上。

5.5.2. 被其他傳遞路徑繞過的避震器

避震器如被鎖上或被其他傳遞路徑繞過，將會大大降低避震器隔震效果。圖 48 顯示一金屬彈簧避震器的不妥善安裝，金屬彈簧旁邊的螺絲杆被不當地扭緊，導致金屬彈簧避震器不能正常伸縮運作，令震動沿著失效的裝置經建築物結構傳至室內。金屬彈簧的伸縮設定經重新設置後，金屬彈簧避震器恢復了正常運作，達至了設計預期的隔震效果。

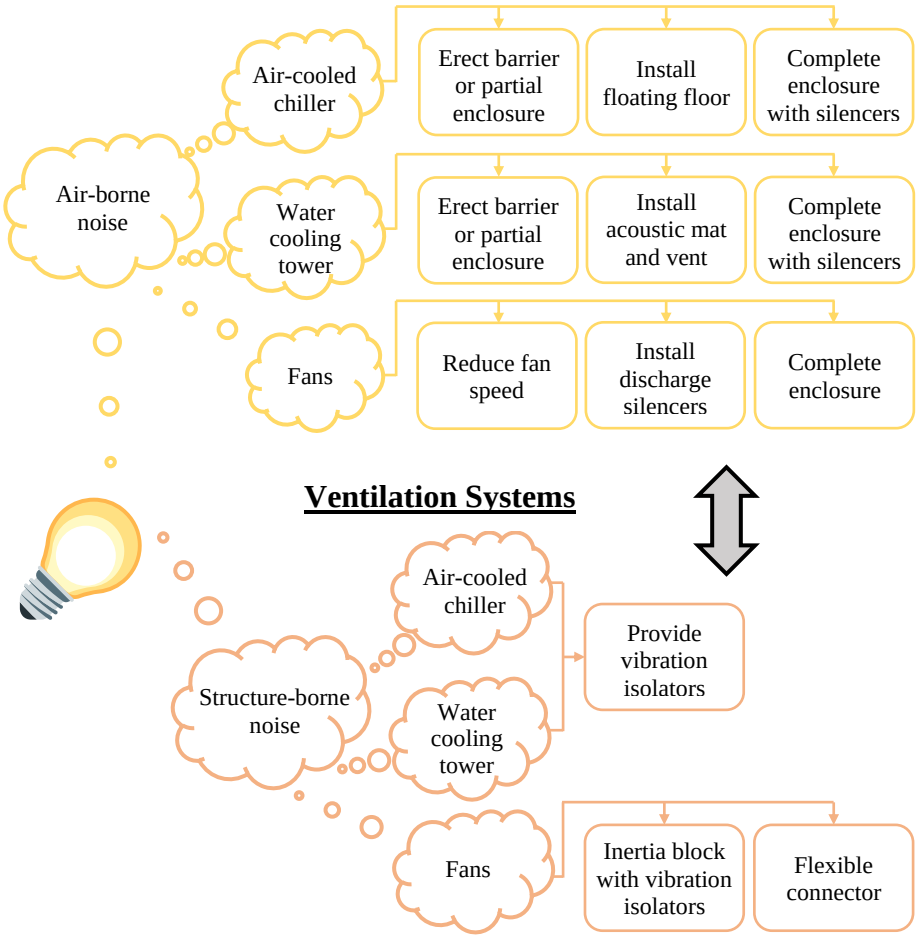
避震器的不妥善安裝

避震器的一般安裝

圖 48： 避震器不妥善安裝的示例

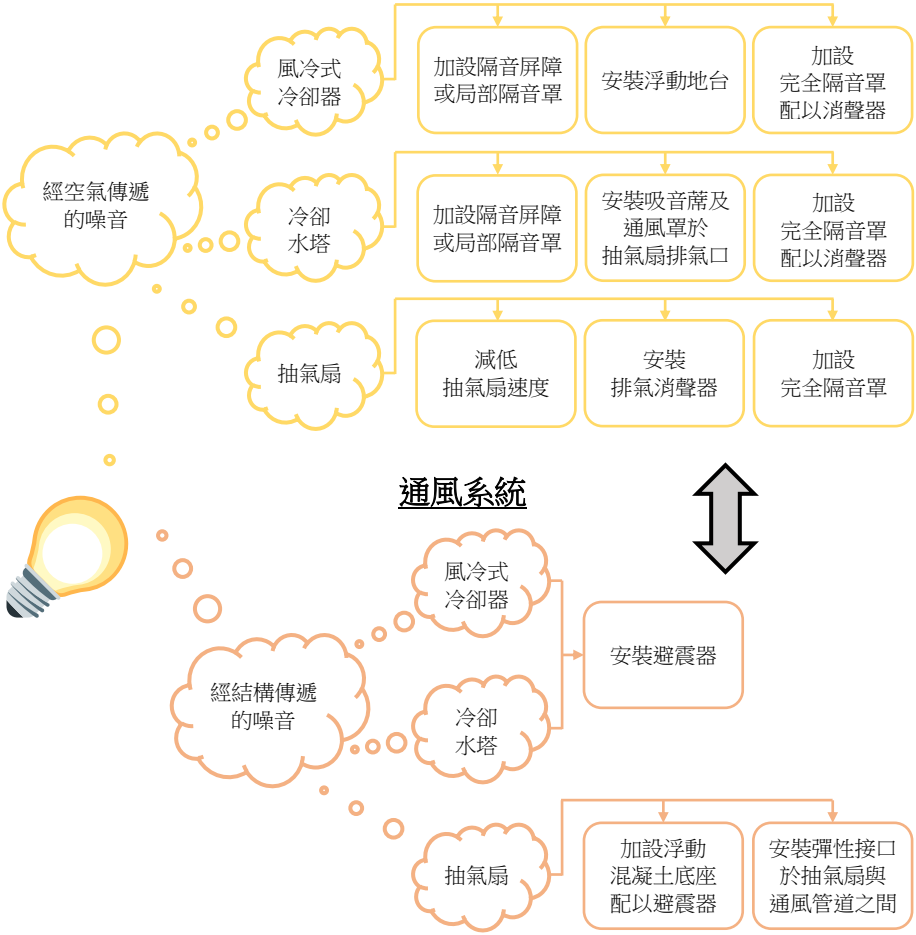
5.6. Important Note

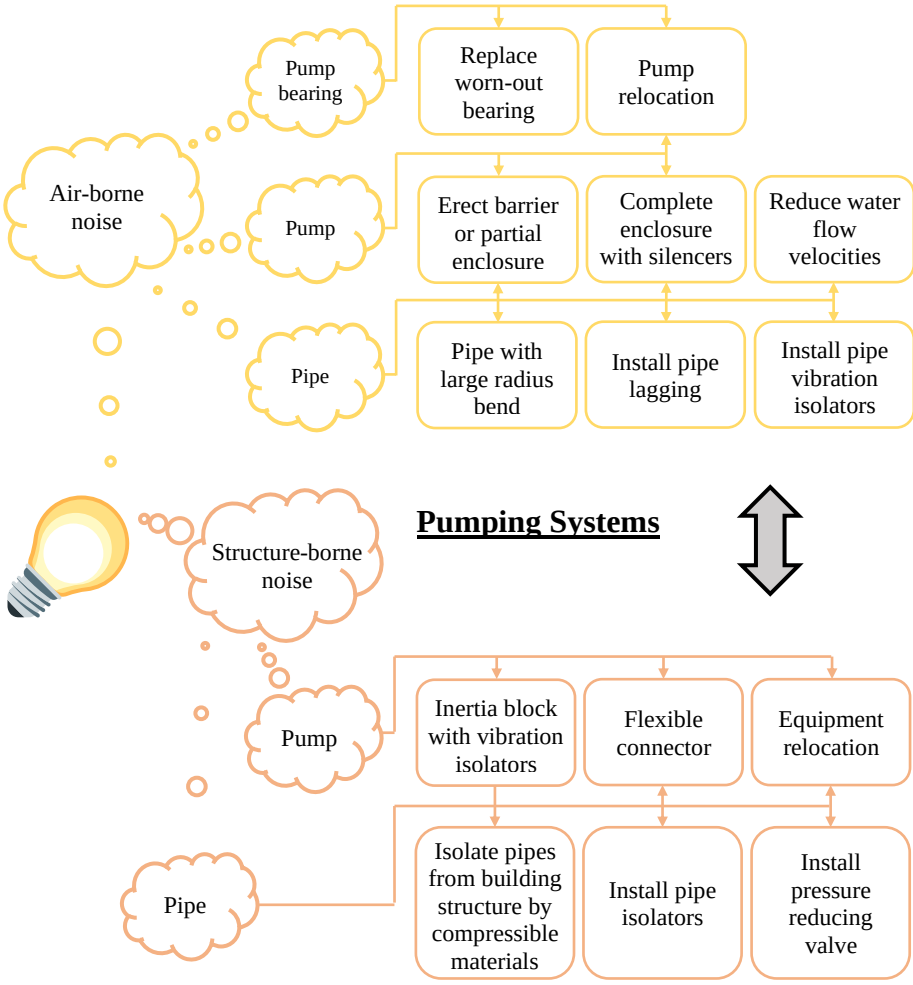
The above only suggests solutions for a particular noise problem. In real life, the noise may be caused by more than one source. In those cases, several remedies may be required simultaneously to solve the problem.

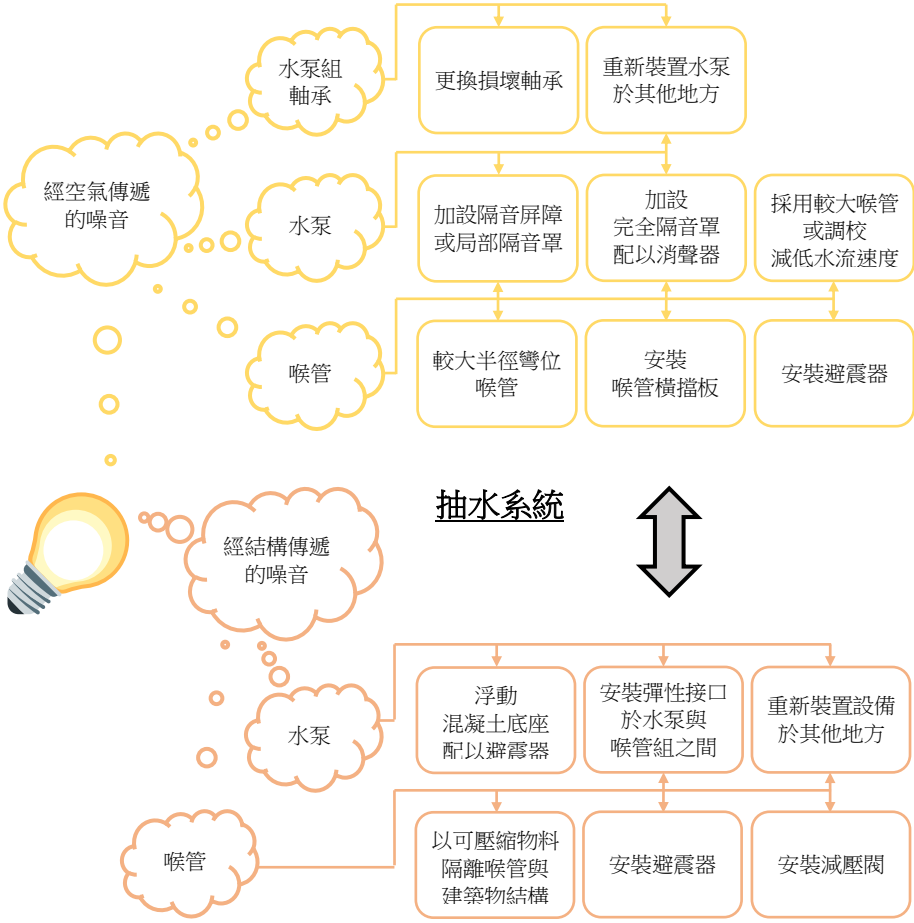


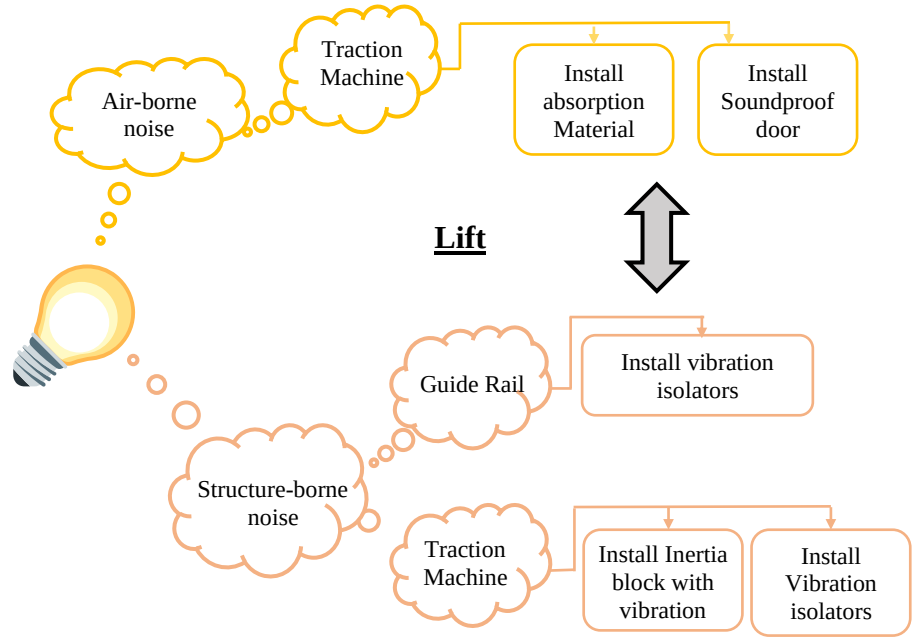
5.6. 重要註解

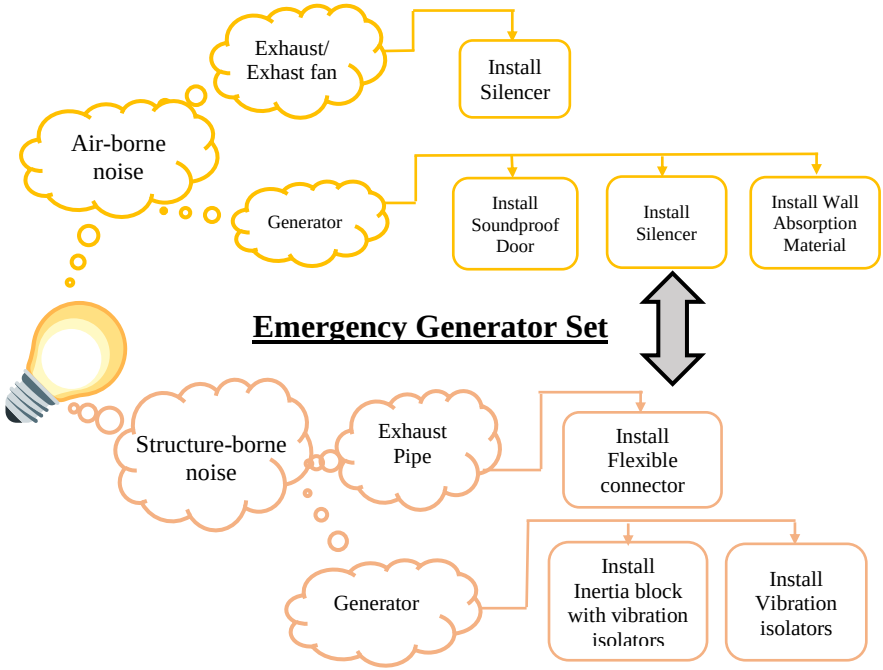
以上的解決方法只為某一特別噪音問題而建議。在真實環境中，噪音可由多過一個音源所引致。在這些情況下，可能需要同時採用多種矯正法去解決該噪音問題。

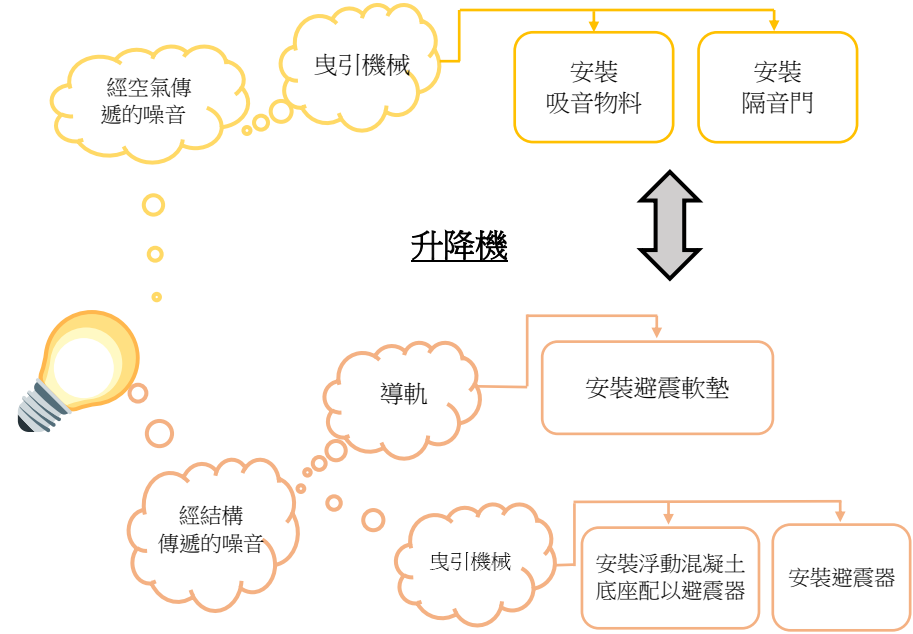


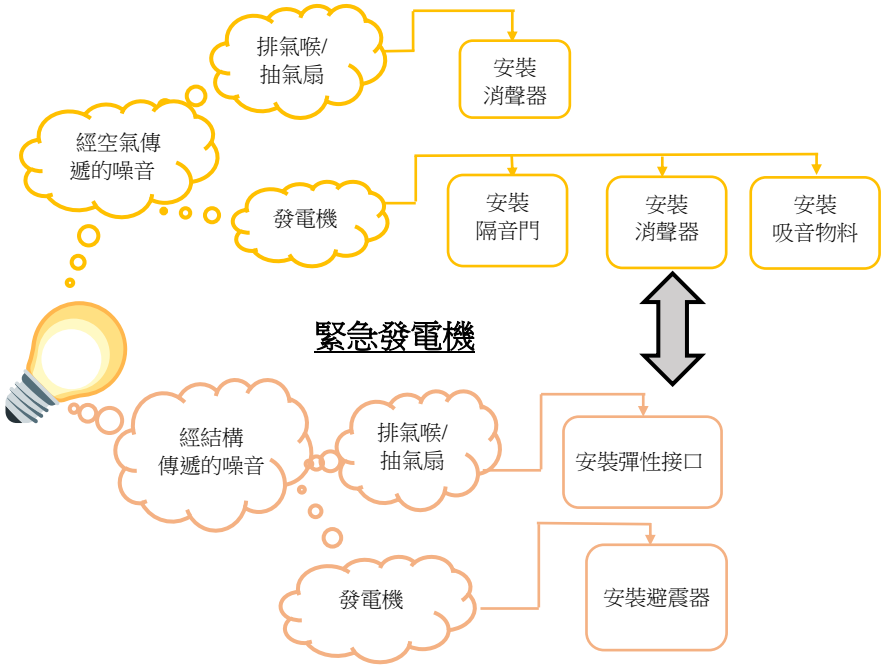

Air-borne noise
Pump bearing
Pump
Pipe
Replace worn-out bearing
Pump relocation
Erect barrier or partial enclosure
Complete enclosure with silencers
Reduce water flow velocities
Pipe with large radius bend
Install pipe lagging
Install pipe vibration isolators
Pumping Systems
Structure-borne noise
Pump
Pipe
Inertia block with vibration isolators
Flexible connector
Equipment relocation
Isolate pipes from building structure by compressible materials
Install pipe isolators
Install pressure reducing valve


經空氣傳遞的噪音
水泵組軸承
水泵
喉管
更換損壞軸承
重新裝置水泵於其他地方
加設隔音屏障或局部隔音罩
加設完全隔音罩配以消聲器
採用較大喉管或調校減低水流速度
較大半徑彎位喉管
安裝喉管橫擋板
安裝避震器
抽水系統
經結構傳遞的噪音
水泵
喉管
浮動混凝土底座配以避震器
安裝彈性接口於水泵與喉管組之間
重新裝置設備於其他地方
以可壓縮物料隔離喉管與建築物結構
安裝避震器
安裝減壓閥


Lift
Air-borne noise
Traction Machine
Install absorption Material
Install Soundproof door
Structure-borne noise
Guide Rail
Install vibration isolators
Traction Machine
Install Inertia block with vibration
Install Vibration isolators


Emergency Generator Set
Air-borne noise
Exhaust/ Exhast fan
Install Silencer
Generator
Install Soundproof Door
Install Silencer
Install Wall Absorption Material
Structure-borne noise
Exhaust Pipe
Install Flexible connector
Generator
Install Inertia block with vibration isolators
Install Vibration isolators


經空氣傳遞的噪音
曳引機械
安裝吸音物料
安裝隔音門
升降機
導軌
安裝避震軟墊
經結構傳遞的噪音
曳引機械
安裝浮動混凝土底座配以避震器
安裝避震器


排氣喉/抽氣扇
安裝消聲器
經空氣傳遞的噪音
發電機
安裝隔音門
安裝消聲器
安裝吸音物料
緊急發電機
經結構傳遞的噪音
排氣喉/抽氣扇
安裝彈性接口
發電機
安裝避震器

5.7. Recommended Practical Remedies for Different Exceedance Levels

The following recommended practical remedies for different noise exceedance levels are for reference purpose only. No guarantee is given to the performance of the application of the recommended remedies. The reader is advised to seek professional advice from independent experts in case of doubts or complicated problems.

Table 5 : Recommended Practical Remedies for Ventilation System Noise

Cause of Problem	Noise Exceedance Level (dB(A))	Recommended Practical Remedies
Air-borne Noise from Chillers	< 10	- Barrier and/or silencers
	10 to 20	- Partial enclosure and silencers
	> 20	- Complete enclosure and silencers - Floating floor
Structure-borne Noise from Chillers	< 20	- Vibration isolators
	> 20	- Relocation
Air-borne Noise from Water Cooling Towers	< 10	- Acoustic mat, barrier and lined vent cowl
	10 to 20	- Partial enclosure and silencers
	> 20	- Complete enclosure and silencers
Structure-borne Noise from Water Cooling Towers	< 20	- Vibration isolators
	> 20	- Relocation
Fan Noise in Ductwork	< 5	- Duct opening away from receiver - Fan speed reduction
	5 to 10	- Silencers
	> 10	- Duct opening away from receivers - Silencers
Structure-borne Noise from Fans	< 20	- Inertia block and vibration isolators
	> 20	- Relocation
Rumbling Duct Noise	< 5	- Stiffening of the vibration duct surface
	> 5	- Damping materials or composite lagging

5.7. 在不同噪音超出水平下所建議之矯正法

以下在不同噪音超出水平下所建議的實用矯正法只作參考用，途對所建議的矯正法並不保證成效。讀者遇疑問或複雜問題時應尋找個別專家給予意見。

表5： 建議的通風系統實用矯正法

問題的來由	噪音超出水平 (分貝(A))	建議的實用矯正法
經空氣傳遞的風冷式冷卻器噪音	< 10	- 隔音屏障和／或消聲器
	10 至 20	- 局部隔罩和消聲器
	> 20	- 完全隔音罩和消聲器 - 浮動地台
經結構傳遞的風冷式冷卻器噪音	< 20	- 避震器
	> 20	- 重新裝置於其他地方
經空氣傳遞的冷卻水塔噪音	< 10	- 吸音蓆、隔音屏障和通風罩
	10 至 20	- 局部隔音罩和消聲器
	> 20	- 完全隔音罩和消聲器
經結構傳遞的冷卻水塔噪音	< 20	- 避震器
	> 20	- 重新裝置於其他地方
抽氣扇於通風管道的噪音	< 5	- 通風管道開口遠離接收者 - 減低抽氣扇速度
	5 至 10	- 消聲器
	> 10	- 通風管道開口遠離接收者 - 消聲器
經結構傳遞的抽氣扇噪音	< 20	- 浮動混凝土底座和避震器
	> 20	- 重新裝置於其他地方
通風管道發出隆隆聲的噪音	< 5	- 加強震動通風管道表面的堅硬性
	> 5	- 具阻尼減震的材料或合成橫擋板

Table 6 : Recommended Practical Remedies for Pumping System Noise

Cause of Problem	**Noise Exceedance Level (dB(A))**	**Recommended Practical Remedies**
Bearing Noise	< 15	- Bearing replacement
	> 15	- Quieter pump or pump relocation
Whining Pump Noise	< 10	- Barrier
	10 to 20	- Partial enclosure
	> 20	- Complete enclosure and silencers
Structure-borne noise from Pumps	< 20	- Inertia block and vibration isolators
		- Flexible connectors
	> 20	- Pump relocation
Ringing pipe noise	< 10	- No sharp bend
		- Pipe lagging
		- Low water flow velocities
		- Rigid mounting around the bend
	> 10	- Partial enclosure
Structure-borne noise from Pipes	< 20	- Isolation of pipes
		- Vibration isolators
		- Pressure reducing valve
	> 20	- Piping system relocation

表6： 建議的抽水系統實用矯正法

問題的來由	噪音超出水平 (分貝(A))	建議的實用矯正法
軸承噪音	< 15	- 更換損壞軸承
	> 15	- 用較寧靜水泵或重新裝置水泵於其他地方
水泵聲噪音	< 10	- 隔音屏障
	10 至 20	- 局部隔音罩
	> 20	- 完全隔音罩及消聲器
經結構傳遞的水泵噪音	< 20	- 浮動混凝土底座和避震器
		- 彈性接口
	> 20	- 重新裝置水泵於其他地方
喉管鐘鳴噪音	< 10	- 避免急變的曲位
		- 喉管橫擋板
		- 低水流速度
		- 以堅硬座架固定曲位
	> 10	- 局部隔音罩
經結構傳遞的喉管噪音	< 20	- 將喉管隔離
		- 避震器
		- 減壓閥
	> 20	- 重新裝置水管設備於其他他方

6. Glossary of Acoustic Terminology

A-Weighted Decibel (dB(A))	- The A-weighted decibel is a unit for measuring noise taking into account the way human ear responds to sound.
Air-borne Noise	- Noise arrives at a point of interest by propagation through air.
Frequency	- The number of repetitive variations of sound pressure per unit of time which is usually stated in Hertz (Hz).
Noise	- Noise is any sound which at the time of reception is unwanted or disturbing.
Sound Power Level	- A measure, in decibels, of the total acoustic power radiated by a given sound source. It is independent of any reference distance or other extraneous factors.
Sound Pressure Level	- A measure, in decibels, of the sound pressure at a particular point. It is dependent upon distance from the source and many other extraneous factors.
Structure-borne Noise	- Noise arrives at a point of interest by propagation through a solid structure.

6. 聲學詞彙

A 加權分貝 (即分貝(A))	- A 加權分貝是量度噪音的單位，反映人類耳朵對噪音的反應。
經空氣傳遞的噪音	- 經空氣傳遞到某一特定地方的噪音。
頻率	- 在每單位時間內聲壓反覆變動的次數。頻率以多少「赫」（Hertz）計，即每秒週期數。
噪音	- 噪音是任何一種被人認為是不需要或令人煩擾的聲音。
聲功率級	- 衡量某一聲源所發出的總聲功率的數值，以分貝表示。它與參考距離或其他外來因素無關。
聲壓級	- 衡量某一點的聲音壓力的數值，以分貝表示。它與聲源的距離及其他外來因素有關。
經結構傳遞的噪音	- 經固體結構傳遞到某一特定地方的噪音。

Appendix I

Statutory Control Over Noise

Noise generated from electrical & mechanical systems is controlled by means of Noise Abatement Notices which may be served on owners or operators of the systems if the emitted noise at a given Noise Sensitive Receiver (NSR), such as a residential building or a school, does not comply with the objective technical criteria in the form of Acceptable Noise Levels (ANL) as set out in the "Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites" (TM).

For a given NSR, with the assessment point at 1 m from the exterior of the building facade the ANL in dB(A) is presented in Table 7. However, under certain conditions specified in the TM, when the assessment point is at an internal location of a building, the ANL shall be 10 dB(A) less than that shown in Table 7 and is presented in Table 8. Most of the building services system noise problems are due to vibration transmitted through building structure and Figure 9 is usually applicable. For details of determination of appropriate ANL, the reader is advised to make reference to the aforementioned TM.

Table 7 : Acceptable Noise Level (dB(A)), at 1 m Façade

Time Period / **Type of Area Containing the NSR**	**Day and Evening (0700 to 2300 hours)**	**Night (2300 to 0700 hours)**
Urban Area	65 – 70	55 – 60
Rural Area	60 – 65	50 – 55

Table 8 : Acceptable Noise Level (dB(A)), at an Internal Location

Time Period / **Type of Area Containing the NSR**	**Day and Evening (0700 to 2300 hours)**	**Night (2300 to 0700 hours)**
Urban Area	55 – 60	45 – 50
Rural Area	50 – 55	40 – 45

法定噪音管制

假如機電系統所發出的噪音在一特定「噪音感應強的地方」（例如：住宅大廈或學校）並不符合「管制非住用處所、非公眾地方或非建築地盤噪音技術備忘錄」內所載的「可接受的噪音聲級」，有關當局會根據該技術備忘錄向該系統之擁有者或操作者發出「消減噪音通知書」，藉此而實施管制。

在一特定的「噪音感應強的地方」，如其評估位置在外牆一米外，其「可接受的噪音聲級 (分貝(A)) 」在表 7 列明。但在以上技術備忘錄列明的某些情況下，而評估位置位於大廈室內，其「可接受的噪音聲級」應較表 7 所載的低 10 分貝(A)，而該「可接受的噪音聲級」在表 8 列明。讀者在決定適用的「可接受的噪音聲級」時，應參考上述提及的技術備忘錄。

表 7： 在外牆一米外的可接受的噪音聲級 (分貝 (A))

時間 噪音感應強 的地方所在地區的種類	日間及晚上 （早上七時至 晚上十一時）	深夜 （晚上十一時至 早上七時）
市區	65 – 70	55 – 60
郊區	60 – 65	50 – 55

表 8： 室內的可接受的噪音聲級 (分貝 (A))

時間 噪音感應強 的地方所在地區的種類	日間及晚上 （早上七時至 晚上十一時）	深夜 （晚上十一時至 早上七時）
市區	55 – 60	45 – 50
郊區	50 – 55	40 – 45

Appendix II

Noise Prediction

A simplified air-borne noise prediction method is given below. The reader is reminded that the results obtained from the following procedures should be regarded as indicative data only. The prediction method is inapplicable to noise transmitted through building structure. In case of any doubts, the reader is advised to seek independent experts for technical advice.

Step 1 – Identification of the Most Affected Noise Sensitive Receivers (NSR)
Any domestic premises, hotel, hostel, temporary housing accommodation, hospital, medical clinic, educational institution, place of public worship, library, court of law or performing arts centre is considered to be a NSR. In general, the nearest NSR facade with windows, doors or other openings with respect to the concerned noise sources shall be identified.

Step 2 – Sound Power Levels (SWLs) for Noise Sources
Typical SWLs of electrical & mechanical equipment are given in Appendix III for reference. The directivity characteristic of some E&M system (e.g. fan & chiller) may need to be considered for a more accurate prediction. Where practicable, sound power level of individual noise source should be referred to the information provided by the respective manufacturers.

噪音聲級的預計

以下陳述一個預計經空氣傳遞的噪音的簡易方法。讀者應緊記從以下程序所得出的預計結果只可作參考。該預計方法並不適用於經建築物結構傳遞的噪音。如遇上任何疑問，讀者應尋找個別專家給予意見。

第一步　確定最受影響的「噪音感應強的地方」的所在位置

任何住用處所、酒店、旅舍、臨時房屋、醫院、診所、教育院校、公眾崇拜地方、圖書館、法庭及演藝中心均被視作「噪音感應強的地方」看待。一般情況下，應確定最接近有關噪音源之「噪音感應強的地方」的窗口、門及其他洞口的外牆。

第二步　噪音源的聲功率級

機電系統設備的典型聲功率級載列於附錄三作為參考。如需獲得更為準確的預計，還需加以考慮機電系統（如風扇，冷凝器等）的聲源方向特性。在實際情況許可下，個別噪音源的聲功率應由有關供應商提供。

Step 3 – Distance Attenuation

The plan distance or where appropriate, the slant distance between individual noise source and the most affected NSR shall be determined and the corresponding distance attenuation shall be obtained from Table 9. These values shall be subtracted from the individual sound power levels for each noise source to give the individual sound pressure levels for each noise source at the NSR.

Step 4 – Summation of Noise Levels

All individual sound pressure levels for each noise source at the NSR shall be added logarithmically in accordance with Table 10 to give a summed noise level.

Step 5 – Correction for Acoustic Reflections

In case the NSR is a building, a positive correction of 3 dB(A) shall be applied to the noise level obtained in Step 4.

Please note that a correction of 3 dB(A) or 6 dB(A) for tonality, impulsiveness or intermittency may be required to apply to the noise level obtained in step 5. For details, please refer to the Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites.

第三步　距離衰減作用

在決定個別噪音源與「噪音感應強的地方」的距離時，應使用平面距離或按適當情況下使用其傾斜距離。而相對的距離衰減系數可參考表 9。從個別噪音的聲功率級減去適當的距離衰減系數，可得出在「噪音感應強的地方」的各噪音源的個別聲壓級。

第四步　噪音聲級的總和

各噪音源在「噪音感應強的地方」所計算得的個別聲壓級應根據表 10 以對數加法計算其總噪音聲級。

第五步　聲音反射的修正

如噪音感應強的地方是一幢大廈，依照第四步計算所得的總噪音聲級應作 + 3 分貝(A) 修正。

請留意在第五步所得的噪音聲級可能須要作 + 3 分貝(A) 或 + 6 分貝(A) 的音調、脈衝或斷續聲音修正。詳情可參閱「管制非住用處所、非公眾地方或非建築地盤噪音技術備忘錄」。

Table 9 : Distance Attenuation at Given Distances

Distance (m)	Attenuation (dB(A))	Distance (m)	Attenuation (dB(A))
1	8	30 to 33	38
2	14	34 to 37	39
3	18	38 to 41	40
4	20	42 to 47	41
5	22	48 to 52	42
6	24	53 to 59	43
7	25	60 to 66	44
8	26	67 to 74	45
9	27	75 to 83	46
10	28	84 to 93	47
11	29	94 to 105	48
12	30	106 to 118	49
13	30	119 to 132	50
14	31	133 to 148	51
15 to 16	32	149 to 166	52
17 to 18	33	167 to 187	53
19 to 21	34	188 to 210	54
22 to 23	35	211 to 235	55
24 to 26	36	236 to 264	56
27 to 29	37	265 to 300	57

For distances greater than 300m, calculation of distance attenuation should be based on standard acoustical principles and practices.

Table 10 : Summation of Noise Levels

Difference in dB(A) Between Two Noise Levels Being Summed	Amount in dB(A) to Add to the Higher Noise Level
0 to 0.5	3.0
1.0 to 1.5	2.5
2.0 to 3.0	2.0
3.5 to 4.5	1.5
5.0 to 7.0	1.0
7.5 to 12.0	0.5
More than 12.0	0

Noise levels should be summed in a pairwise fashion when Table 10 is used and the final total rounded to the nearest whole dB(A), with values of 0.5 or more being rounded upwards.

表 9： 在某一指定距離的距離衰減系數

距離 (米)	修正 (分貝(A))	距離 (米)	修正 (分貝(A))
1	8	30 至 33	38
2	14	34 至 37	39
3	18	38 至 41	40
4	20	42 至 47	41
5	22	48 至 52	42
6	24	53 至 59	43
7	25	60 至 66	44
8	26	67 至 74	45
9	27	75 至 83	46
10	28	84 至 93	47
11	29	94 至 105	48
12	30	106 至 118	49
13	30	119 至 132	50
14	31	133 至 148	51
15 至 16	32	149 至 166	52
17 至 18	33	167 至 187	53
19 至 21	34	188 至 210	54
22 至 23	35	211 至 235	55
24 至 26	36	236 至 264	56
27 至 29	37	265 至 300	57

此表只適用於三百米內的距離。倘距離超過三百米，距離衰減系數的計算需考慮到一般聲學原理及慣例。

表 10： 噪音聲級的加法

兩個要計算的噪音聲級 的分貝(A) 差距	在較高的噪音聲級加上 的分貝(A) 數值
0 至 0.5	3.0
1.0 至 1.5	2.5
2.0 至 3.0	2.0
3.5 至 4.5	1.5
5.0 至 7.0	1.0
7.5 至 12.0	0.5
12.0 以上	0

在使用表 10 時，噪音聲級應以一對對的加上，而最後的總數應以四捨五入，小數到一個完整的分貝(A) 。

Example:
Two equipment (a fan and a pump) having sound power levels of 95 dB(A) and 100 dB(A) respectively are installed outdoors. The most affected noise sensitive receiver is identified to be a residential flat which is at 20 m and 25 m away from the fan and the pump, respectively. The sound pressure level at the residential flat contributed by the two equipment is estimated below.

NSR (Step 1)	**Noise Sources**	**SWL (dB(A)) (Step 2)**	**Distance (m)**	**Distance Attenuation (dB(A)) (Step 3)**	**Noise Level (dB(A))**
Residential Flat	Fan	95	20	34	61
	Pump	100	25	36	64
Summed Noise Level (dB(A)) (Step 4)					66
Correction for Acoustic Reflection (dB(A)) (Step 5)					3
Noise Level at NSR (dB(A))					69
ANL (see Table 7)					60
Noise Exceedance					9
Recommended Practical Remedies (see Table 5 and Table 6 in Section 5.7): - barrier for the pump - silencer for the fan					

例子：

兩設備（抽氣扇和水泵）放置於室外，其聲功率級分別為 95 分貝(A)及 100 分貝(A) 。而最受影響的「噪音感應強的地方」確定為一居住單位，分別距離抽氣扇及水泵 20 米和 25 米。以下估計該兩設備所發出的噪音在居住單位旳噪音聲壓級。

噪音感應強的地方 (第一步)	**噪音來源**	**聲功率級 (分貝(A))**	**距離 (米)**	**距離衰減系數 (分貝(A)) (第三步)**	**噪音聲級 (分貝(A))**
居住單位	抽氣扇	95	20	34	61
	水泵	100	25	36	64
噪音聲級總和 (分貝(A)) (第四步)					66
聲音反射的修正數值 (分貝(A)) (第五步)					3
「噪音感應強的地方」的噪音聲級 (分貝(A))					69
「可接受的噪音聲級」(參考表 7)					60
噪音超出水平					9
建議的實用矯正方法 (參考段節 5.7 的表 5 及表 6) - 隔音屏障 - 抽風扇消聲器					

Appendix III

Typical Sound Power Levels of Electrical & Mechanical Equipment

The following sound power levels for various rating of equipment are given for reference purpose only (See *Table 11* to *Table 14*). Where practicable, the sound power level of the concerned equipment should be referred to the respective manufacturers. Super low noise model of Electrical & Mechanical Systems on the market could be 6 to 9 dB(A) lower.

Table 11 : Typical Sound Power Levels of Air-cooled Chillers

Cooling Capacity (Ton)	Sound Power Level (dB(A))
50	100
100	102
150	103
200	105
250	106
300	106
350	107
400	109

Table 12 : Typical Sound Power Levels of Water Cooling Towers

Horsepower of Fan (hp)	Sound Power Level (dB(A))
10	96
20	99
30	101
40	102
50	103
60	104
70	105
80	105

機電系統的典型聲功率級

不同功率設備的聲功率級可參考表 11 至表 14。實際情況許可下，應詢問相關供關商有關設備旳聲功率級。 市場上超靜音機電系統的聲功率級可減少 6 至 9 分貝(A)。

表 11： 風冷式冷卻器的典型聲功率級

冷凍量 (冷噸)	聲功率級 (分貝(A))
50	100
100	102
150	103
200	105
250	106
300	106
350	107
400	109

表 12： 冷卻水塔的典型聲功率級

抽氣扇的馬力 (馬力)	聲功率級 (分貝(A))
10	96
20	99
30	101
40	102
50	103
60	104
70	105
80	105

Table 13 : Typical Sound Power Levels of Fans

Volume Flowrate (m^3/hr)	Sound Power Level (dB(A)) at Static Pressure	
	125 Pa	750 Pa
1700	79	95
8600	83	99
17000	85	101
34000	89	105
43000	90	107
86000	93	110
170000	97	113

Table 14 : Typical Sound Power Levels of Pumpsets

Rotational Speed (rpm)	Horsepower of Pumpset (hp)	Sound Power Level (dB(A))
3600	5 to 10	100
	11 to 20	103
	21 to 30	105
	31 to 50	107
	51 to 100	109
1800	5 to 10	92
	11 to 20	92
	21 to 30	94
	31 to 50	97
	51 to 100	100

表 13： 抽氣扇的典型聲功率級

通風量 (立方米／小時)	**聲功率級 (分貝(A))**	
	125 帕斯卡	**750 帕斯卡**
1700	79	95
8600	83	99
17000	85	101
34000	89	105
43000	90	107
86000	93	110
170000	97	113

表 14： 水泵組的典型聲功率級

每分鐘轉速	**水泵組的馬力 (馬力)**	**聲功率級 (分貝(A))**
3600	5 至 10	100
	11 至 20	103
	21 至 30	105
	31 至 50	107
	51 至 100	109
1800	5 至 10	92
	11 至 20	92
	21 至 30	94
	31 至 50	97
	51 至 100	100

Complete Enclosures

When a noise reduction of 20 dB(A) or more is required, it is generally necessary to use a complete enclosure if the noise problem is a result of air-borne noise transmission. The enclosure should be internally lined with 50 mm thick sound absorbing material (e.g. fibre glass). A variety of materials can be utilized for fabricating an enclosure. The sound transmission loss for enclosures using different materials are given in Table 15. Ventilation of enclosures should not be overlooked as most equipment, such as motors, requires an adequate air supply either to prevent overheating or to enable them to function efficiently. A silenced ventilation system incorporating silencers at the air intakes and discharge openings should be employed (see Figure 16 and Figure 28).

Table 15 : Sound Insulation Materials for Enclosures

Material	Thickness (mm)	Surface Density (kg/m^2)	Sound Reduction Index, Rw (dB)
Plastered Brick Wall	125	240	45
Compressed Strawboard	56	25	38
Acoustic Panel (Sandwich type steel sheet with fibre glass)	50	27	26
Chipboard	19	11	27
Plaster board	9	9.5	28
Plywood	18	10	27

Figure 49 : Complete Enclosures
(Image Courtesy of Kinetics Noise Control Inc.)

完全隔音罩

假若噪音問題是由空氣傳遞產生而需要作超過 20 分貝(A) 的消減，一般需要應用完全隔音罩。隔音罩內應襯上五十毫米厚的吸音材料（例如：玻璃纖維），而隔音罩本身可用各類材料造成，表 15 列出不同隔音罩材料的聲音透射損失值。隔音罩內的通風亦不應被忽略，因為多數機動設備（例如：馬達）均需要足夠流通空氣以防止過熱及使其有效地運作。應採用在進氣口及排氣口配備消聲器的寧靜通風系統（參考圖 16 及圖 28）。

表 15： 隔音罩的隔聲物料

材料	厚度 (毫米)	表面質量 (千克／平方米)	計權隔聲量, Rw (分貝)
磚牆	125	240	45
馬糞紙	56	25	38
隔音板 (鋼板夾玻璃纖維)	50	27	26
硬紙板	19	11	27
石膏板	9	9.5	28
夾板	18	10	27

圖 49： 完全隔音罩

(蒙 Kinetics Noise Control Inc. 公司特許轉載此圖)

Partial Enclosures

Partial enclosures are structures erected around a source of noise, but not fully enclosing the source and leaving space for natural ventilation, which will be effective only when there is no line of sight between the noise source and the receiver. The use of partial enclosures has advantages over complete enclosures in terms of cost, accessibility, and ventilation, but design and construction should be done carefully. Ideally, a reduction of up to 20 dB(A) can be achieved.

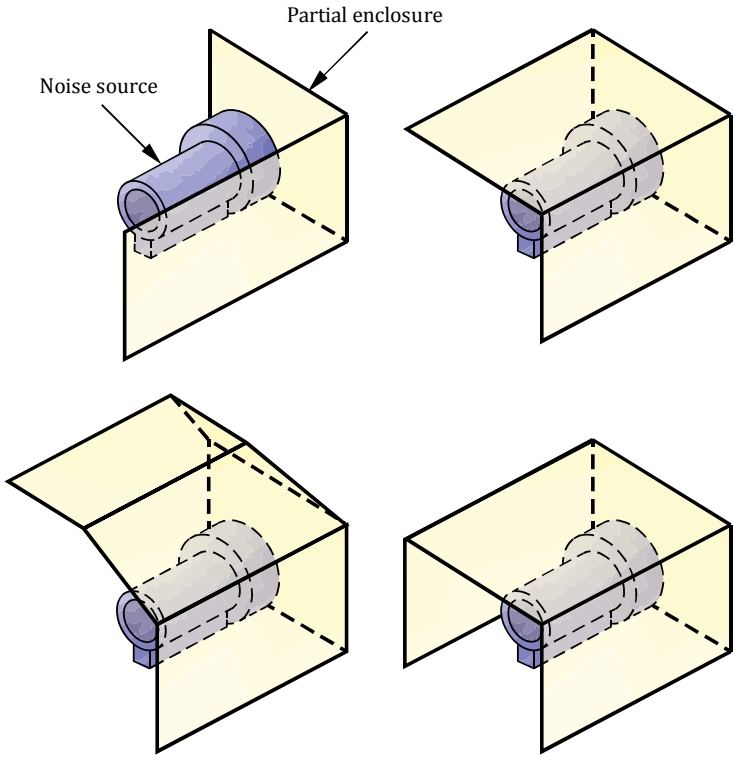


Figure 50 : Partial Enclosures

局部隔音罩

局部隔音罩是圍封噪音來源的建造物，它並不將聲源完全圍封及留下空間作自然通風之用。局部隔罩只會在接收者不能直接看到噪音源的情況下才能有效。在成本、檢查及通風方面，局部隔音罩都比完全隔音罩優勝，但在設計及建造時應加倍仔細。在最理想的情況下，可消減音量達至 20 分貝(A) 。

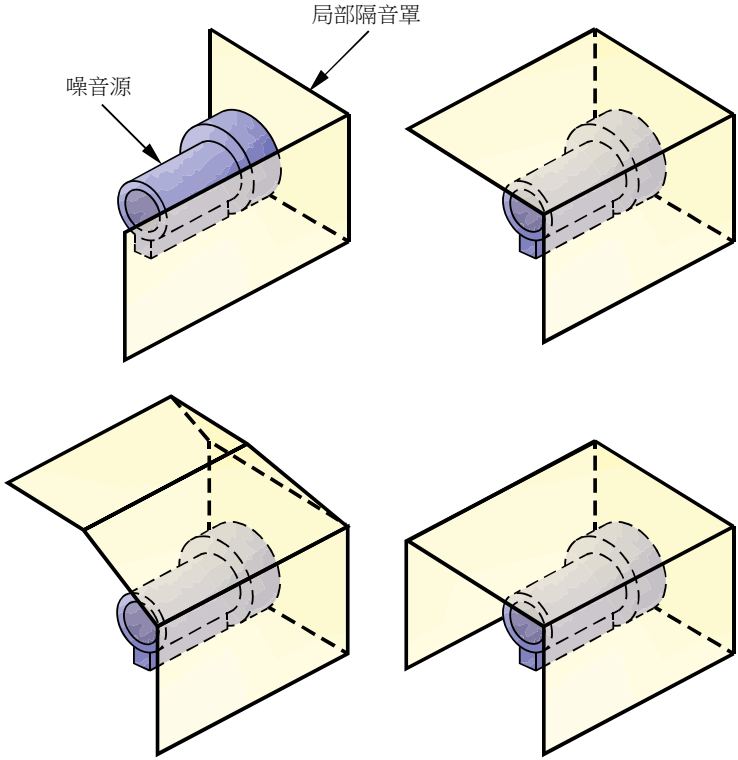


圖 50： 局部隔音罩

Barriers

To be effective, an acoustic barrier needs to be placed as close as possible either to the noise source or the receiving position. There should be no gap or joint in the barrier through which noise will leak. The surface density of the barrier must be at least 10 kg/m^2. Ideally, the length of the barrier should be at least 5 times its height. Line of sight between the source and the receiver must be cut off completely.

A reduction of noise level of between 5 dB(A) to 10 dB(A) can generally be resulted. Noise reduction will be greater if the barrier is lined with sound absorbing material at the surface of the barrier facing the noise source or is extended as high as possible above the line of sight.

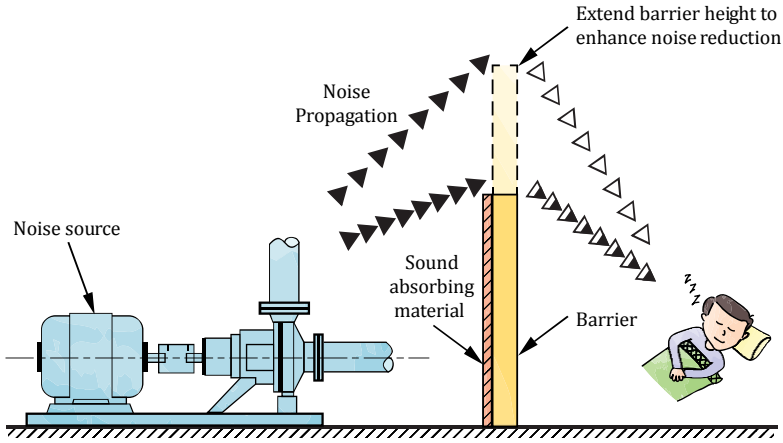


Figure 51 : Barriers

隔音屏障

隔音屏障應盡量放低噪音源或受噪音影響的地方以達到最佳隔音效果。隔音屏障應沒有可滲漏噪音的間隙及接口。隔音屏障的表面質量不能少於每平方米 10 千克。在最理想的情況下，屏障的長度不應少於其高度的五倍，而受噪音影響的地方亦應該不能看見噪音源。

一般而言，採用隔音屏障可減低噪音聲級介乎 5 至 10 分貝(A)。假若在面對噪音源的隔音屏障表面襯上吸音物料或增加隔音屏障高度以高於視線，噪音消減效果將更加明顯。

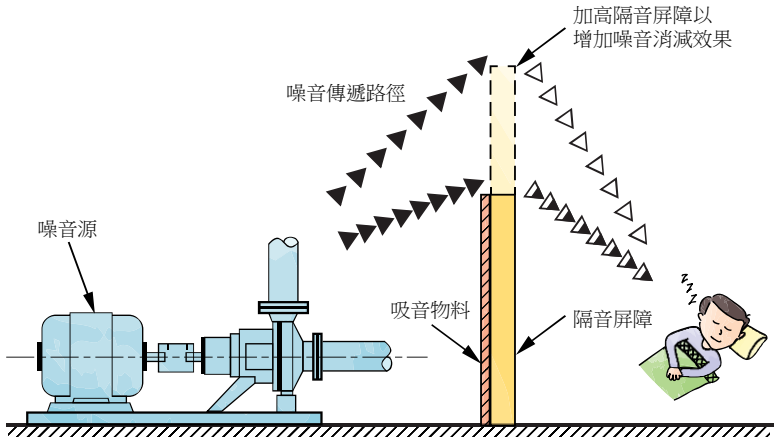


圖51： 隔音屏障

Appendix VII

Inertia Blocks

A heavy and rigid inertia block is often used as the base for equipment in order to reduce motion, lower the centre of gravity, minimize the effect of unequal weight distribution of the support equipment, and stabilize the entire vibration isolation system. Generally an inertia block should be at least 15cm thick and very stiff and rigid to avoid significant flexure in any direction. Table 16 shows a recommended weight of inertia block for various rating of equipment.

However, when the mass of the supported equipment is enormous, there may be no need for additional mass in the form of inertia blocks; a rigid frame to support (e.g. Reinforced Concrete Beam) the entire assembly may be sufficient.

Table 16 : Guide for Inertia Block Selection

Equipment	Power (hp)	Speed (rpm)	Weight Ratio (1) at		
			Min Area (2)	Normal Area (3)	Critical Area (4)
Centrifugal or Axial Fans	< 3	All	--	--	2
	3 to 125	< 600	--	2	3
		600 to 1200	--	--	2
		> 1200	--	--	2
	> 125	< 600	--	2	3
		600 to 1200	--	2	2
		> 1200	--	2	2
Pumpset	< 20	450 to 900	1.5	2 to 3	3 to 4
		900 to 1800	2.5	1.5 to 2.5	2 to 3
		> 1800	2.5	1.5 to 2.5	2 to 3
	20 to 100	450 to 900	2 to 3	2 to 3	3 to 4
		900 to 1800	1.5 to 2.5	2 to 3	2 to 3
		> 1800	1.5 to 2.5	1.5 to 2.5	2 to 3
	> 100	450 to 900	2 to 3	3 to 4	3 to 4
		900 to 1800	2 to 3	2 to 3	2 to 3
		>1800	1.5 to 2.5	2 to 3	2 to 3

Note:

1. Weight Ratio: Weight of inertia block over weight of equipment mounted on inertia block.
2. Minimum Area: Basement or on-grade slab location.
3. Normal Area: Upper floor location but not above or adjacent sensitive areas.
4. Critical Area: Upper floor location above or adjacent sensitive areas.

浮動混凝土底座

重型及堅硬的浮動混凝土底座常用作機械設備的底座以減少擺動、降低重心、減低不均衡重量分佈於所支撐設備的影響及穩定整個避震系統。一般來說，浮動混凝十底座應不少於 15 厘米厚及非常堅硬和挺直以防向外撓曲。表 16 顯示用於不同功率機電設備的浮動混土底座的建議重量。

但當受支撐的設備已經非常沉重 (例如：冷卻水塔) 則採用堅硬的框架支撐整個機械組件已經足夠 (例如：鋼筋混凝土樑) ，而毋須以浮動混凝土底座增加質量。

表 16： 浮動混凝土底座選擇指引

設備	功率 (馬力)	每分鐘轉速	重量比重 (1) 於以下情況		
			次要區域 (2)	正常區域 (3)	嚴謹區域 (4)
離心式和軸心式的抽氣扇	< 3	全部	--	--	2
	3 至 125	< 600	--	2	3
		600 至 1200	--	--	2
		> 1200	--	--	2
	> 125	< 600	--	2	3
		600 至 1200	--	2	2
		> 1200	--	2	2
水泵組	< 20	450 至 900	1.5	2 至 3	3 至 4
		900 至 1800	2.5	1.5 至 2.5	2 至 3
		> 1800	2.5	1.5 至 2.5	2 至 3
	20 至 100	450 至 900	2 至 3	2 至 3	3 至 4
		900 至 1800	1.5 至 2.5	2 至 3	2 至 3
		> 1800	1.5 至 2.5	1.5 至 2.5	2 至 3
	> 100	450 至 900	2 至 3	3 至 4	3 至 4
		900 至 1800	2 至 3	2 至 3	2 至 3
		>1800	1.5 至 2.5	2 至 3	2 至 3

註解：

1. 重量比重：浮動混凝土底座的重量除以浮動混凝土底座上之設備的重量。
2. 次要區域：地下室及地面混凝土板位置
3. 正常區域：高層位置，但不在敏感地區的鄰近或上面。
4. 嚴謹區域：高層位置，在敏感地區的鄰近或上面。

Appendix VIII

Vibration Isolators

Motor-driven equipment vibrates during operation. The method of reducing vibration transmission to other sensitive areas is to separate the equipment from the supporting structure by vibration isolators. Generally, there are two types of vibration isolators, metal springs and isolation pads that are widely used for vibration isolation.

i) Metal Springs

Springs are particularly applicable where heavy equipment is to be isolated or where the required static deflections exceed 12.5mm. Static deflection of a spring is a value specified by the suppliers. Selection of appropriate springs is important as this may result in poor isolation efficiency or even amplification of vibration, especially in the case that the vibration frequency is extremely low.

The most important feature of spring mounts is to provide good isolation due to its ability of withstanding relatively large static deflection. Metal springs however have the disadvantage that at very high frequencies vibration can travel along the spring into the adhered structure. This is normally overcome by incorporating a neoprene pad in the spring assembly so that there is no metal-to-metal contact. Most commercially available springs contain such a pad as a standard feature. Figure 52 shows some common spring mountings. Table *17* provides the minimum static deflection required for achieving particular isolation efficiency at different equipment speeds.

(Image Courtesy of Kinetics Noise Control Inc.)

Figure 52 : Metal Springs

避震器

馬達驅動的設備會在操作期間震動。可使用避震器分隔設備與其支架結構以減低傳送到其他敏感地區的震動。一般來說，金屬彈簧及避震軟墊是其中兩種被廣泛用於隔震的避震器。

i) 金屬彈簧

彈簧特別適用於隔離重型設備或在避震器需要高於 12.5 毫米靜載重撓度的情況下使用。避震器供應商均會列明彈簧本身的靜載重撓度。不合適的彈簧選型不但會導致避震效能差甚至會增大震動 (特別在設備震動頻率極之低的情況下) ，因此選用適當的彈簧尤其重要。

彈簧避震器擁有很大的靜載重撓度使其能提供良好的隔震功能。不過，金屬彈簧亦有其缺點，高頻率的震動能沿著彈簧傳遞到其連接的結構上。此情況通常可透過應用橡膠軟墊於彈簧組件上以避免金屬間之接觸來克服。大多市場上的標準彈簧避震器都裝有此類軟墊。圖 52 顯示各種常見彈簧避震器。

表 17 顯示在不同的機械轉速及隔震效率要求下，避震器所需的最低靜載重撓度。

（蒙 Kinetics Noise Control Inc. 公司特許轉載此圖）

圖 52： 金屬彈簧避震器

Table 17 : Minimum Static Deflection for Various Speed of Machines

Machine Speed (rpm)	Minimum Static Deflection at Various Transmissibility (mm)			
	1%	5%	10%	15%
3600	14.0	1.5	1.0	0.5
2400	30.5	3.5	2.0	1.5
1800	56.0	6.0	3.0	2.0
1600	71.5	7.5	4.0	3.0
1400	91.5	10.0	5.5	4.0
1200	124.5	13.5	7.0	5.0
1100	150.0	15.5	8.5	6.0
1000	180.5	19.0	10.0	7.0
900	223.0	23.5	12.5	9.0
800	282.0	30.5	15.5	11.0
700	--	38.5	20.5	14.0
600	--	53.5	28.0	19.5
550	--	63.5	33.0	23.0
400	--	117.0	61.0	43.5
350	--	155.0	81.5	56.0
300	--	211.0	109.5	76.5
250	--	--	157.5	109.5

Note:

1. The above static deflections are obtained by theoretical calculations, which are for reference only.
2. For fair and high degree of vibration isolation, transmissibility should be less than 2.86%, or the ratio of driving frequency of source to natural frequency of mounting system should be equal or greater than 6.
3. It is strongly advised that the ratio of driving frequency of source to natural frequency (f_n) of the mounting system should not be less than 1.4, otherwise vibration amplification may likely occur.
4. The reader is also recommended to consult independent experts for installation involving vibration isolators with high static deflections.
5. Natural frequency (f_n) $= \frac{15.8}{\sqrt{static\ deflection\ (in\ mm)}}$

表 17： 在不同機械轉速下所需的最低靜載重撓度

機械的每分鐘轉速	在不同的震動傳遞率下所需的最低靜載重撓度（毫米）			
	1%	**5%**	**10%**	**15%**
3600	14.0	1.5	1.0	0.5
2400	30.5	3.5	2.0	1.5
1800	56.0	6.0	3.0	2.0
1600	71.5	7.5	4.0	3.0
1400	91.5	10.0	5.5	4.0
1200	124.5	13.5	7.0	5.0
1100	150.0	15.5	8.5	6.0
1000	180.5	19.0	10.0	7.0
900	223.0	23.5	12.5	9.0
800	282.0	30.5	15.5	11.0
700	--	38.5	20.5	14.0
600	--	53.5	28.0	19.5
550	--	63.5	33.0	23.0
400	--	117.0	61.0	43.5
350	--	155.0	81.5	56.0
300	--	211.0	109.5	76.5
250	--	--	157.5	109.5

註解：

1. 以上所載的靜載重撓度是根據理論性計算所得，作為讀者參考之用。
2. 對於一般和高度的隔震，傳遞率應少於 2.86%，或者震源的驅動頻率與安裝系統的自然頻率之比應等於或大於 6 。
3. 極力建議震源的驅動頻率與安裝系統的自然頻率(f_n)之比不應小於 1.4，否則可能會發生震動放大。
4. 讀者在安裝高靜載重撓度的避震器時應尋找獨立專家意見。
5. 自然頻率 $(f_n) = \frac{15.8}{\sqrt{\text{靜載重撓度（毫米）}}}$。

ii) Isolation Pads

Isolation pads can be made of rubber, neoprene, glass fibre or combination of them. They are relatively cheap, easy for installation and replacement, and have the advantage of good high-frequencies isolation. However, attention should be given to the life of the isolation pads as some of them can be damaged by overload or low temperature. Figure 53 shows some common isolation pads.

(Image Courtesy of Kinetics Noise Control Inc.)

Figure 53 : Isolation Pads

ii)避震軟墊

避震軟墊以塑膠、橡膠、玻璃纖維或混合上述物質製成。價格比較便宜、容易安裝及更換，並能提供優良的高頻隔震效果。由於軟墊在負荷過重或處於極低溫的情況下可能會有所損壞，固應關注其耐用性。圖 53 顯示各種常用的避震軟墊。

（蒙 Kinetics Noise Control Inc. 公司特許轉載此圖）

圖 53： 避震軟墊

Appendix IX

Silencers

Silencers are commercially available devices that allow the passage of air while restricting the passage of sound generated from air distribution equipment. They subdivide the air flow into several passages each lined with perforated sheet backed by mineral wool or glass fibre. For rectangular duct silencer, the cross section is normally required to be the same as the duct in which it is installed due to the space limitation. To reduce the pressure loss and airflow generated noise, the silencer splitter shall be designed with streamline-shaped nose, such as dolphin nose, bull nose or round nose. Silencer lengths are normally in step of 300 mm starting from 600 mm to 3,600mm. While for circular silencer, the outer diameter is normally larger than the duct in which it is installed since absorption lining is required to be fixed inside the outer shell. Silencer lengths are normally the same as or 2 times the inner diameter of the silencer. They are generally specified by the insertion loss in decibels (dB) in each octave band, so that the degree of match with the sound power distribution of the noise source over the frequencies may be judged. The other important parameter associated with silencers is the resistance to air flow. The use of silencer will inevitably increase the load of the fan and it is essential for engineers to consider both the acoustic and air flow performances during the design stage.

Circular Silencer
(Image Courtesy of NAP Acoustics (Far East) Limited)

Rectangular Silencer
(Image Courtesy of Industrial Acoustics Company (HK) Ltd)

Figure 54 : Silencers

消聲器

消聲器是市場上供應的商業化設備，其容許空氣通過之同時亦能限制由空氣配給設備產生出來的噪音。消聲器細分為多條空氣通道，而每條通道均鄰接襯以礦棉或玻璃纖維的有孔薄板。長方形消聲器的橫切面面積會與安裝在通風管道的橫切面一樣，以減低壓力損失以及空氣決速通過而產生出噪音。消聲器分隔板會設計成不同的流線型狀，例如海豚鼻、公牛鼻或橢圓形等。長方形消聲器的長度一般為 600 毫米至 3,600 毫米，每級以 300 毫米為單位上升。圓筒形消聲器的外徑會比通風管道較大，因吸聲物料會安裝在消聲器的外殼上。而圓筒形消聲器的長度一般為內徑的兩倍。消聲器普通以其在每一個頻程聲級的插入損失值作為規格，促使能判斷它與噪音源在不同頻程的聲功率級分佈的吻合程度。另外與消聲器關連的重要參數還包括空氣流動的阻力。採用消聲器無可避免增加風扇的阻力，工程師在設計階段必須同時考慮聲學及空氣流動兩者的表現。

圓筒形消聲器
（蒙 NAP 聲學工程（遠東）有限公司特許轉載此圖）

長方形消聲器
（蒙雅士消聲器材（香港）有限公司特許轉載此圖）

圖 54： 消聲器

Floating Floors

A floating floor is a floor which is supported by a structural slab but is completely isolated from the structural slab by resilient support members, so it is nowhere in rigid contact with the structure slab. The floating floor acts as a protective covering for the structural slab. Impacts, no matter in the forms of vibration or noise, on the floating floor will be absorbed substantially before reaching the structural slab. As a result, the room below the structural slab is much quieter than it will be if the same impacts directly strike the structural slab.

Figure 55 shows two types of floating floors which are supported resiliently on isolation pads and fiberglass insulation board. To prevent potential damage of a floating floor, it must be structurally designed for proper strength and the applied load should be within the design limits and uniformly applied. For any type of floating floor, the construction must be monitored carefully to ensure proper installation as it is usually very difficult to remedy defects after completion of the installation.

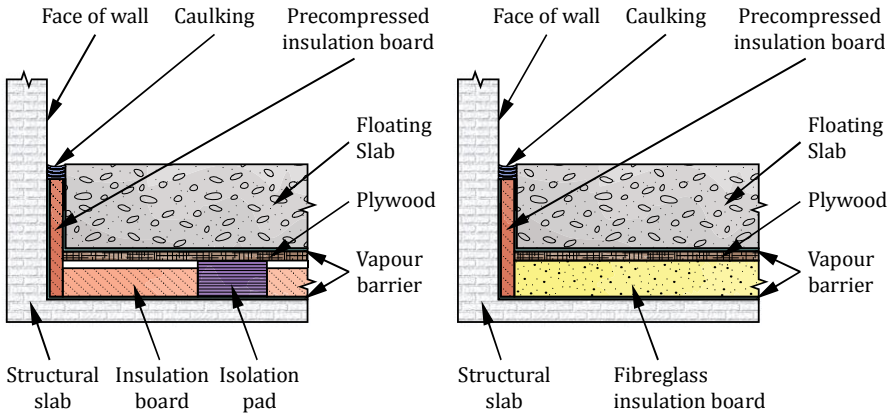


Figure 55 : Floating Floors

浮動地台

浮動地台由結構地台所承托但以有彈力的支撐構件將兩者完全分隔，因此在任何地方均不會有直接接觸。浮動地台可作為結構地台的保護層，任何震動或噪音的衝擊在到達結構地台前均被其大量吸收，因此在結構地台下的地方會較該衝擊直接落於結構地台時寧靜。

圖 55 顯示兩種類型的浮動地台，分別由避震軟墊及玻璃纖維絕緣板所承托。為防止浮動地台可能的損壞，其結構應有適當的強度。另外，負荷重量亦需要在設計範圍內平均地施加在浮動地台上。任何一種浮動地台，在建成後均非常困難作任何修改，因此在建造時應小心檢查以確保其安裝適當。

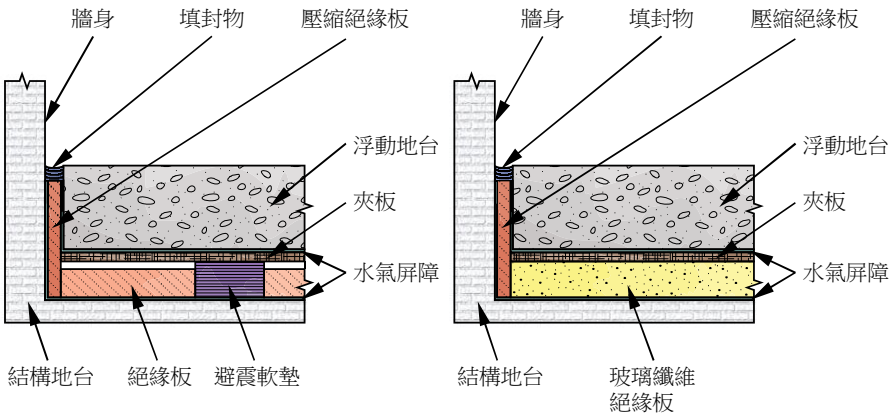


圖 55： 浮動地台

Acoustic Louvres

Similar to silencers, acoustic louvres are also commercially available devices that allow the passage of air while restricting the passage of sound generated from noisy spaces. They act much the same as ordinary louvres but consist of hollow acoustic vanes instead of flat sheet vanes. The acoustic vanes, with the underside (the side facing the noise source) formed from perforated sheet, are filled with sound absorptive material. A typical construction of an acoustic louvre is shown in Figure 56. The acoustic performance of an acoustic louvre is specified by the transmission loss in decibels (dB) in each octave band. This enables a direct comparison to be made between the performance of the louvre and a solid wall/structure which it probably replaces. Since an acoustic louvre is a very short attenuator, it is appropriate only where the length of space is restricted and the noise reduction requirement is low. Acoustic louvres are frequently installed in the facades of buildings where they are architecturally acceptable and provide a requisite amount of noise attenuation to prevent creating unacceptably high noise levels outside.

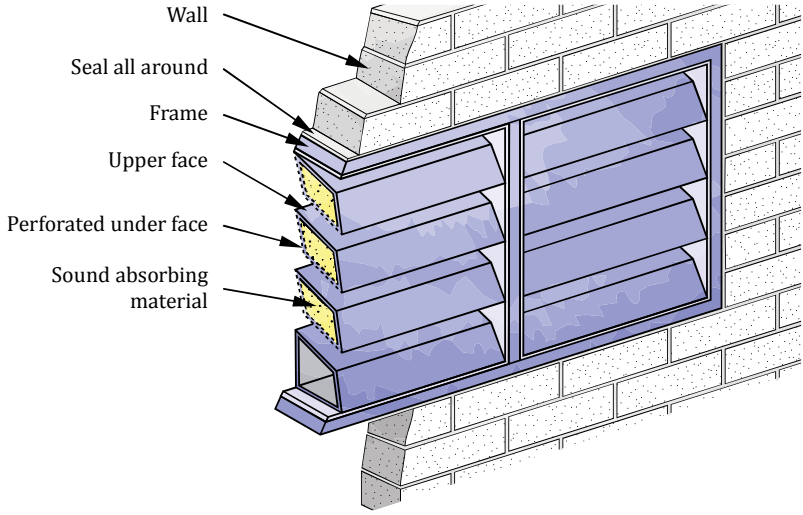


Figure 56 : Acoustic Louvres

隔聲百葉窗

跟消聲器相似，隔聲百葉窗也是市場上供應的商業化設備，其容許空氣通過之同時亦能限制由嘈吵的空間溢出的噪音。跟一般百葉窗的平板導風葉不同，隔聲百葉窗由空心導風葉構成，內裡填滿吸音物料，其底面（面向噪音源）配以有孔的薄板。圖 56 顯示一典型隔聲百葉窗旳構造。隔聲百葉窗普遍以其在每一個頻程聲級的透射損失值作為規格，這樣可以直接比較百葉窗及其替代的牆或結構的隔聲表現。由於隔聲百葉窗是一個非常短的消聲器，它只適宜在空間受長度限制而噪音消減要求低的情況下使用。由於外觀被接受，所以隔聲百葉窗經常安裝在建築物外牆以提供所需的噪音消減避免在建築物外產生不能接受的噪音。

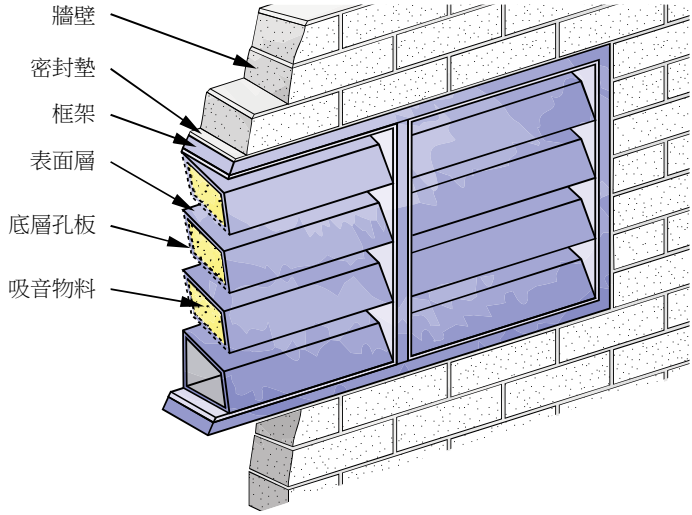


圖 56： 隔聲百葉窗

Appendix XII

Soundproof Doors

The sound insulation provided by a door depends not only on the type of door but also on installation details (e.g. the gaskets around the perimeter). Generally, rubber or plastic compression seals, which are set around the door edges, provide the best result of insulation when closing the door. The degree of sound insulation of a door is usually specified by sound transmission class (STC).

Table *18* gives typical STC values of some conventional types of doors. However, if doors are required to have STC values greater than 30, it is recommended that packaged soundproof door units are to be employed. They are usually supplied with them fixed in a frame together with suitable seals. A variety of soundproof doors is available in the market, offering average STC values up to 45 which is equivalent to a 112mm brick wall.

Table 18 : Sound Transmission Class of Doors

Type of Door	Thickness (mm)	Surface Density (kg/m^2)	Sound Transmission Class
Hollow-core wood	45	7	20
Solid-core wood	45	17	26
Steel-faced door	51	16	26
Fibreglass-reinforced plastic door	45	12	24
Fire rated metallic door	53	61	45

Figure 57 : Soundproof Door
(Image Courtesy of NAP Acoustics (Far East) Limited)

隔音門

門的隔音能力不只取決於門的類型也取決於安裝細節 (例如：門四邊的襯墊) 。一般來說，橡膠或塑膠壓成的密封墊置門的四邊在關上門後提供最好的隔音效果。門普遍以聲音透射等級作為規格，表 18 顯示一些普通門的聲音透射等級。但是，如果所需的門要有大於 30 的聲音透射等級，應選用套裝隔音門。通常隔音門在交收時已經裝置在框架上及配備適當密封墊。在市場上有很多隔音門可供選擇，平均的聲音透射等級可達至 45 (相等於 112 毫米磚牆) 。

表 18： 門的聲音透射等級

門類型	厚度 (毫米)	表面質量 (千克／平方米)	聲音透射等級
空心木門	45	7	20
實心木門	45	17	26
鋼面門	51	16	26
玻璃纖維強化膠門	45	12	24
金屬防火門	53	61	45

圖 57： 隔音門
（蒙 NAP 聲學工程（遠東）有限公司特許轉載此圖）

Appendix XIII

Vibration Identification Guide

The causes of excessive vibration or noise of a machine can be detected by vibration measurements at various frequencies. A vibration identification guide is given in Table 19.

Table 19 : Vibration Identification Guide

Cause of Excessive Vibration	Frequency Relative to Machine Speed
Unbalance	1 × rpm
Defective sleeve bearing	(10 to 100) × rpm
Misalignment of coupling or bearing	2 × rpm, sometimes (1 or 3) × rpm
Bent shaft	(1 or 2) × rpm
Mechanical looseness	(1 or 2) × rpm
Defective belt	(1 or 2) × belt rpm

辨別震動來源指引

量度一台機械的不同頻率震動可有助明瞭過量的震動或噪音的成因。有關辨別震動來源指引可見表 19。

表 19： 辨別震動來源指引

過量震動的來源	相對機器運行轉速 (rpm) 的頻率
失衡	1 × rpm
軸承損壞	(10 至 100) × rpm
聯軸節及軸承直線排列差誤	2 × rpm，有時 (1 或 3) × rpm
變彎的軸心	(1 或 2) × rpm
機械組件鬆脫	(1 或 2) × rpm
皮帶損壞	(1 或 2) × 皮帶 rpm

Appendix XIV

Guidelines for Centrifugal and Axial Fan Installation

Turbulence results in the generation of noise and an increased static pressure drop in the system. Therefore, the air flow at the entrance and exit of a fan should be as smooth as possible to minimise the generation of turbulence. For this reason, fitting (such as elbows and transitions) should not be placed too close to a fan. This is illustrated in Figure 58 and Figure 59, which show examples of good and bad air flow conditions for fan installation.

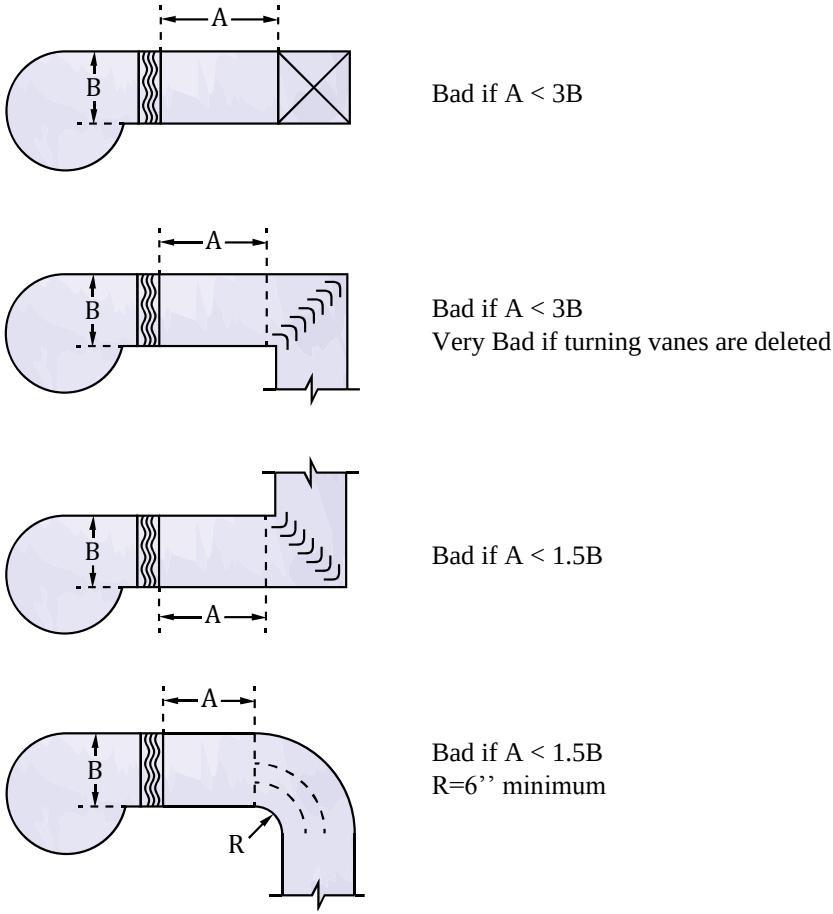


Figure 58 : Guidelines for Centrifugal Fan Installation

離心式及軸心式抽氣扇的安裝指引

湍流會產生噪音及增加系統上的靜壓降。所以在抽氣扇入口和出口的空氣流動應保持暢順以減少湍流的產生。正因如此，通風管道配件 (例如：管道曲和轉接位) 不應安裝在接近抽氣扇的位置。圖 58 及圖 59 顯示安裝抽氣扇時良好和差劣的空氣流動情況的比較例子。

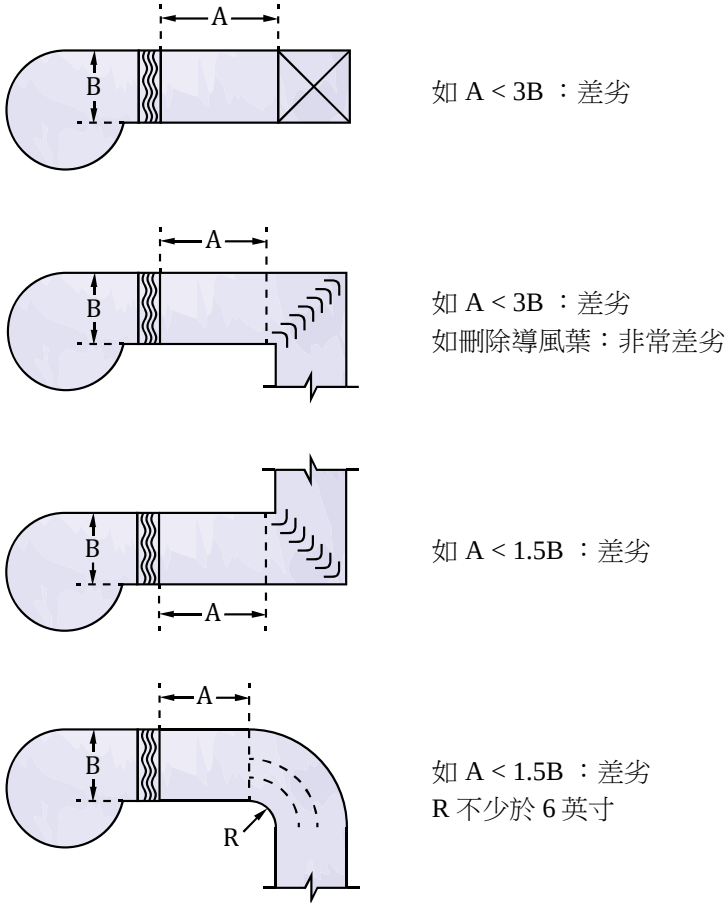


圖 58： 離心式抽氣扇安裝指引

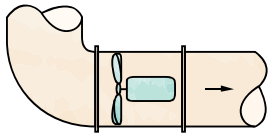
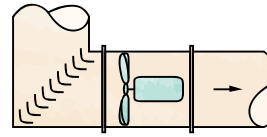
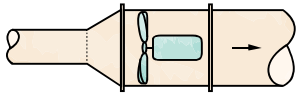
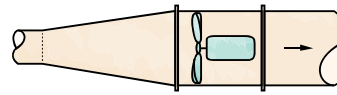
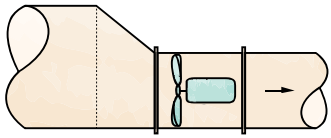
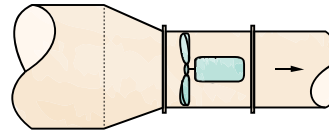
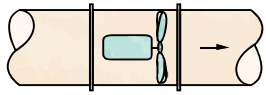
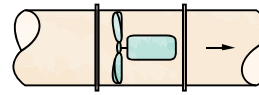
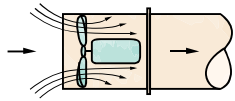
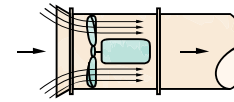
Not Recommended	Recommended
	
Upstream radius elbow creates imbalance at inlet.	Square inlet elbow with vanes
	
Abrupt inlet transition causes turbulence.	Gradual (1:7) expansion of inlet duct
	
Asymmetrical transition creates excess turbulence and noise.	Symmetrical transition minimize turbulence and noise.
	
Motor upstream of impeller increases turbulence and noise.	Motor downstream from impeller minimizes turbulence and noise.
	
A flanged fan inlet reduces performance and increases noise	A bellmouth inlet guides air into the impeller blade tips.

Figure 59 : Guidelines for Axial Fan Installation

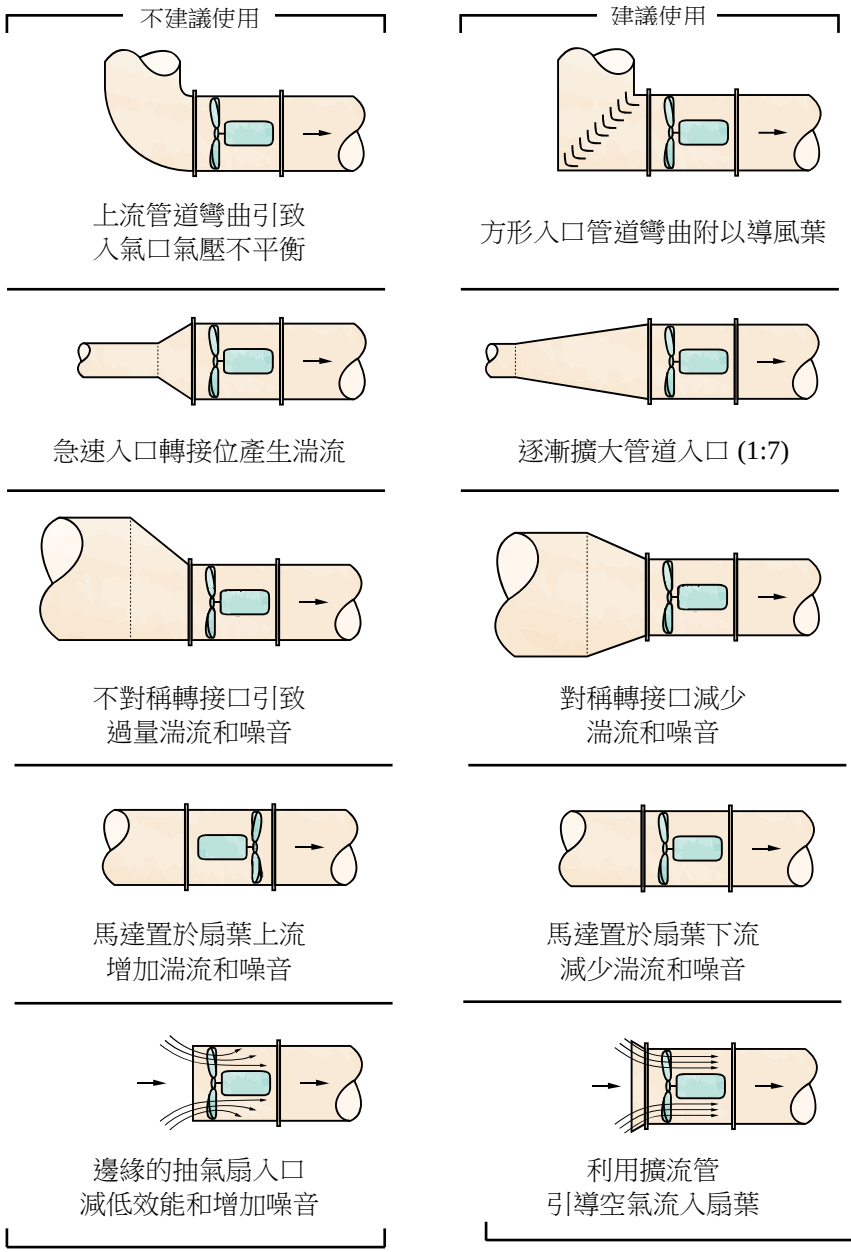
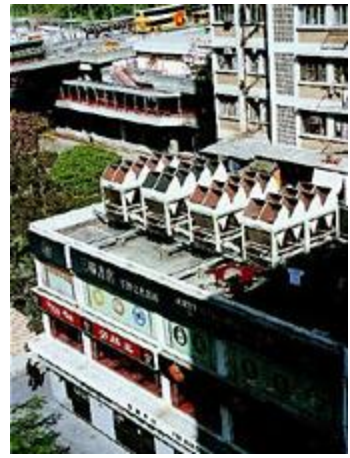


圖 59 ： 軸心式抽氣扇安裝指引

Examples of Practical Noise Control Measures

Some noise control measures are shown in Figure 60 to Figure 65 for reference.

Installation of Noise Barrier



Orientation of Exhaust Outlet
Away from Noise Sensitive Receivers

(Before Noise Mitigation)

(After Noise Mitigation)

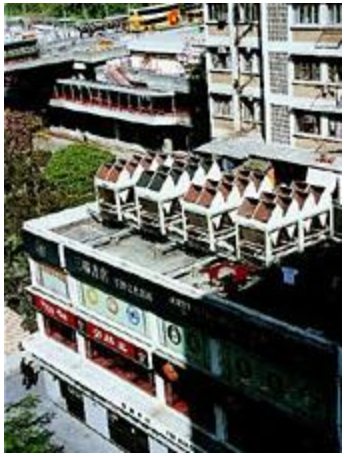
Installation of Complete Enclosure and Discharge Silencers
Noise Reduction: > 20 dB(A)

Figure 60 : Examples of Noise Control Measures for Ventilation Systems

實用噪音控制措施例子

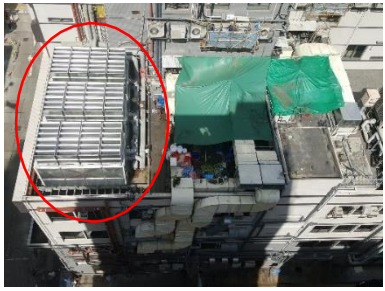
圖 60 至圖 65 顯示一些噪音控制措施以作參考。

安裝隔音屏障



設置排氣口的方向於
遠離噪音感應強的地方

(噪音緩減前)



(噪音緩減後)

安裝完全隔音罩和排氣口消聲器
噪音消減：>20 分貝(A)

圖 60： 通風系統噪音控制措施的示例

(Before Noise Mitigation)

(After Noise Mitigation)

Installation of Acoustic Panels /Lourvres around the Chiller Sets

Figure 61 : Examples of Noise Control Measures for Air Cooled Chillers

(Before Noise Mitigation)

(After Noise Mitigation)

Installation of a Discharge Silencer

Noise was significantly reduced after and was found way below the ambient level (57 dB(A))

Figure 62: Examples of Noise Control Measures for Ventilation System for Lift Machine Room

(噪音緩減前)

(噪音緩減後)

為冷凝器機組安裝隔聲板或隔聲百葉

圖 61： 風冷式冷凝器系統噪音控制措施的示例

(噪音緩減前)

(噪音緩減後)

安裝排氣口消音器

噪音明顯消減，遠遠低過背景噪聲級(57 分貝(A))

圖 62： 升降機機房之通風系統噪音控制措施的示例

(Before Noise Mitigation)

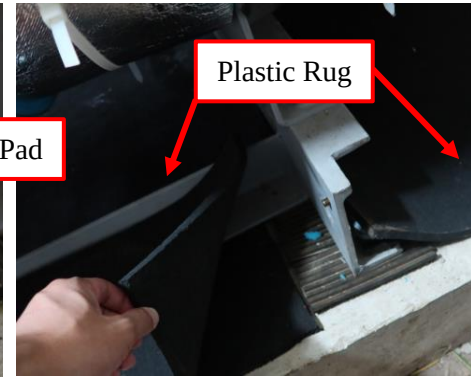
(After Noise Mitigation)

Installation of Silencers for the Exhaust Air System of Generators Sets

Noise Reduction: > 25 dB(A)

Figure 63: Examples of Noise Control Measures for Emergency Generator Exhaust

Small isolation pads (Neoprene pads) were inserted between the machinery and the ground.



A plastic rug was placed over the ground, covering the base of the machinery

*Figure 64: Examples of **Inefficient** Noise Control Measures for Chillers*

(噪音緩減前)

(噪音緩減後)

為緊急發電機排氣系統安裝消聲器

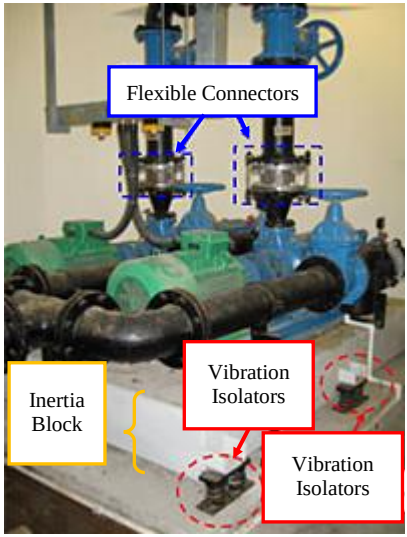
噪音消減：>25 分貝(A)

圖 63： 緊急發電機系統噪音控制措施的示例

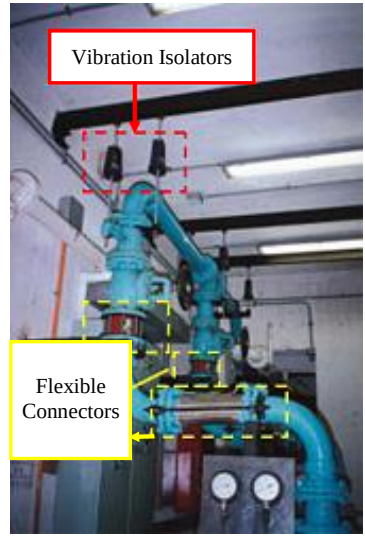
在機器和地面間安裝細小避震軟墊
(橡膠墊)

在機器底部和地面蓋上塑膠毯

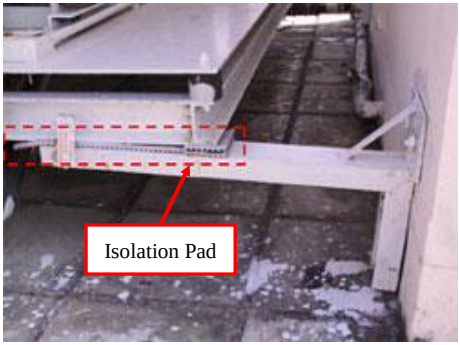
圖 64： <u>欠成效</u>的冷凝器噪音控制措施的示例



Installation of Inertia Block, Vibration Isolators and Flexible Connectors



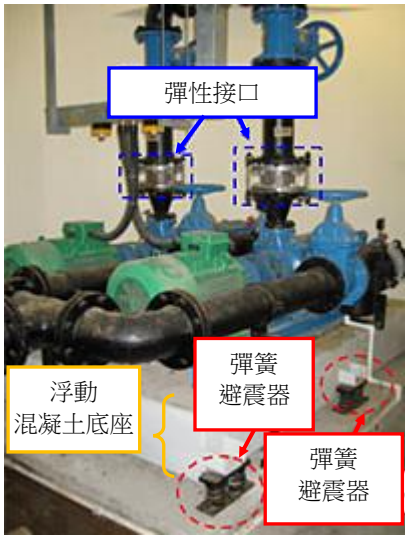
Installation of Spring Hangers and Flexible Connectors



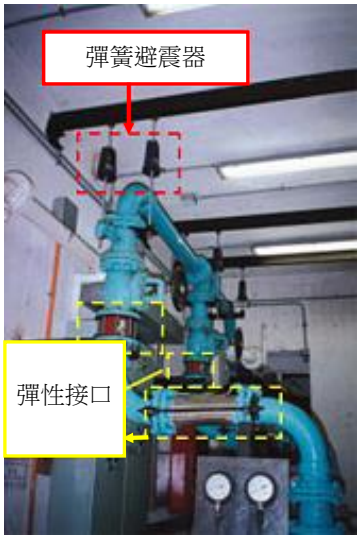
Installation of Isolation Pads

Insertion of Flexible Sleeve at Wall Penetration Locations of Pipes

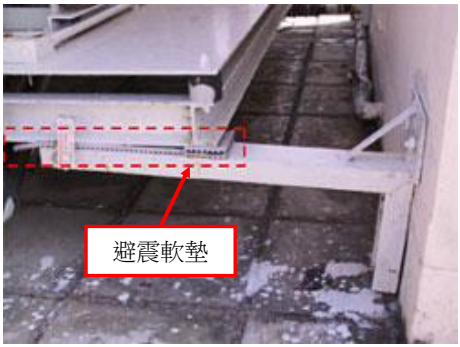
Figure 65 : Examples of Noise Control Measures for Pumping Systems



安裝浮動混凝土底座、
彈簧避震器及彈性接口



安裝彈簧避震器及彈性接口



安裝避震軟墊

以可壓縮物料包裹
穿透建築物結構的喉管

圖 65： 抽水系統噪音控制措施的示例

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Appendix XVII

Other Relevant Noise Control Materials

Description	Web Site Address
Noise Control Ordinance, Cap. 400	https://www.elegislation.gov.hk/hk/cap400
A Concise Guide to the Noise Control Ordinance	https://www.epd.gov.hk/epd/sites/default/files/epd/gn_pdf/GN2014P152-2014c-e.pdf
Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites	https://www.epd.gov.hk/epd/sites/default/files/epd/english/envir_standards/files/GN2014P108-2014c-e.pdf

其他有關噪音控制的資料

名稱	互聯網網址
噪音管制條例 (第 400 章)	https://www.elegislation.gov.hk/hk/cap400!zh-Hant-HK
噪音管制條例簡介	https://www.epd.gov.hk/epd/sites/default/files/epd/gn_pdf/GN2014P152-2014c-c.pdf
管制非住用處所、非公眾地方或非建築地盤噪音技術備忘錄	https://www.epd.gov.hk/epd/sites/default/files/epd/tc_chi/envir_standards/files/GN2014P108-2014c-c.pdf