A Practical Guide
for the Reduction of
Noise from Construction Works
消減建築噪音實用指南

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A PRACTICAL GUIDE FOR 
THE REDUCTION OF NOISE FROM CONSTRUCTION WORKS 

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INTRODUCTION

This booklet provides information on quiet construction equipment and working practices which will be useful in reducing noise from construction works. It is intended that the booklet will be updated and expanded from time to time and the Environmental Protection Department would therefore be pleased to receive any additional relevant information.

The booklet is arranged in three parts:

Part I: Noise from General Construction Equipment
Part II: Noise from Piling Operations
Part III: Construction Noise Control Specifications and Clauses

Part I and II of this booklet are for the benefit of contractors and other readers who might have little acoustical background. Part I describes ways in which noise from commonly used items of construction equipment can be reduced and Part II deals with noise from piling operations. Sound data for various items of equipment obtained from manufacturers and research institutions are also presented for information and comparison so that equipment producing less noise can be selected for the construction works. All of the silenced equipment described in Parts I and II are commercially available either in Hong Kong or overseas.

Part III gives examples of noise control specifications and clauses which can be incorporated into construction work contracts. The inclusion of such clauses is a useful preventive measure and can help to avoid unexpected and expensive noise control work during the construction phase.

The inclusion of any information of any company or product or reference to brand names of any particular product in this booklet does not in any way imply recommendation or endorsement by the Hong Kong Government. The inclusion or reference is for demonstration purpose only and the non-inclusion of any product or company herein shall not be construed as disapproval of the Hong Kong Government. The data regarding any product herein have been certified to be accurate by relevant manufacturers or their authorized agents or representatives. However, no warranty or guarantee whatsoever is or shall be construed as having been given by the Hong Kong Government in respect of any product referred to herein. Readers are advised to seek independent expert or technical advice regarding the operation, use, installation, maintenance or otherwise of any product referred to herein.
1. CONCRETE OR ROCK BREAKING EQUIPMENT

1.1 Noise sources and noise control techniques

Breaking of concrete or rock will normally involve the use of hand-held or excavator mounted breakers. In the case of pneumatic breakers, the noise is caused primarily by three sources, as shown in Figure 1. The relative magnitude of each source will vary according to the type of equipment. It should be noted that the elimination of only one source will not significantly reduce the overall noise level if other sources are left untreated.

![Figure 1 Pneumatic breaker noise sources](image)

The principal noise sources are:

(a) Exhaust noise

Exhaust noise is generated by sudden release of exhaust air from the pneumatic breaker. This effect can be minimized by the use of a muffler which reduces the exhaust velocity of the air through a longer exhaust passage, thus reducing the impulsive character of the noise. In general, the use of a muffler can reduce exhaust noise by up to 15 dB(A) (see Figure 2).
(b) Body radiated noise

Body radiated noise originates from the cylinder enclosure and the front head enclosure, and is caused by the impact of the piston on the anvil and hammer body.

Some manufacturers provide mufflers which enclose the complete cylinder. These mufflers can reduce the body radiated noise by as much as 6 dB(A) (see Figure 2). It should be noted that wrapping the body with canvas or cloth will not result in any comparable reduction in noise.

c) Ringing noise

The ringing of the steel bit causes a distinctive high frequency noise which is a result of the vibration caused by the impact of the bit on a rigid surface.

This high frequency ringing noise can be reduced by applying a constrained damping layer to the steel bit. There are commercially made dampers which incorporate steel collars to keep the damping material in place and protect it from abrasion (see Figure 3). The noise reduction by this method is about 3 dB(A). Such a noise reduction can subjectively reduce the degree of annoyance.

Figure 2 Muffler design to reduce the exhaust noise and body radiated noise
(Courtesy of Ingersoll—Rand Co.)
1.2 Silenced equipment

(a) Hand-held pneumatic breakers

Hand-held pneumatic breakers fitted with mufflers and damping collars as described in Section 1.1 are commercially available. Most of these are manufactured to meet either the European Economic Community directives or the noise emission standards established by United States Environmental Protection Agency. The average purchase cost for a silenced breaker is about 6% higher than that for a standard one. It should be noted, however, that due to the back pressure caused by the exhaust muffler, the power of silenced breakers may be slightly less than that of the standard item. Information on silenced type pneumatic breakers can be obtained from several manufacturers, including those listed in Appendix A.

(b) Hand-held hydraulic breakers

Unlike hand-held pneumatic breakers, hand-held hydraulic breakers do not generate exhaust noise. Noise from hand-held hydraulic breakers is, therefore, less disturbing and the noise level is typically 7 dB(A) lower than that of a comparable-sized pneumatic breaker. However, this is not the case for large capacity breakers for which body radiated noise is dominant.
The cost of adopting a hydraulic system is comparable to that of a pneumatic system and can in fact be more economical, particularly when the lower long-term operating costs are taken into account. Information on hand-held hydraulic breakers can be obtained from several manufacturers, including those listed in Appendix B.

(c) Excavator-mounted breakers

Excavator-mounted pneumatic or hydraulic rock breakers are amongst the noisiest items of general construction equipment, generating noise levels comparable to those caused by piling by diesel hammers. Figure 4 shows a commercially made hammer bracket which is applicable to a limited range of hydraulic breakers. The bracket is made of special alloy and the inside of it is lined with sound insulation material. The whole assembly, when fitted onto the hammer, may achieve a noise reduction of up to 10 dB(A). The cost of installing such bracket to a hydraulic breaker varies with the size and capacity of the breaker but would typically be around 10%–20% of the cost of the hammer itself.

![Figure 4 Sound proof hammer bracket](image)

Figure 4  Sound proof hammer bracket  
(Courtesy of Krupp Industrietechnik)

1.3 Alternative concrete or rock breaking techniques

Described below are a number of quiet alternative concrete/rock breaking techniques available which can replace the conventional impact tools. Details of the manufacturers can be found in Appendix C.
(a) **Excavator-mounted hydraulic concrete crusher**

The crusher breaks concrete or other hard materials by bending and snapping, thus avoiding the generation of impact noise (see Figure 5). It is also suitable for breaking concrete foundations, asphalt pavement, floor slabs, columns and other concrete structures where reinforcing is to be cut or exposed. According to manufacturer's data, a crushing force of approximately 90 tonnes exerted by the jaws can be achieved. Breaking the concrete causes negligible noise and the overall noise level is no higher than that emitted by an excavator. In addition, the set of jaws can be replaced by a bucket with no major alteration for excavation purpose.

(b) **Thermal lance**

Use of a thermal lance is a quiet technique for boring or cutting which can be used in combination with other methods of demolition. The equipment cuts concrete or brick structures into small pieces for subsequent removal by an excavator. A thermal lance consists of a steel tube packed with steel rods and connected to an oxygen cylinder via a hose and a pressure regulator valve. Heat from the ignited oxygen stream maintains combustion of the steel with a flame temperature of about 3500°C which is capable of cutting or burning holes through concrete (see Figure 6).

(c) **Non-explosive demolition agent**

This commercially available method works on the principle that a chemical agent is put into holes drilled in rock or concrete and the agent gradually hardens and expands resulting in the propagation of cracks and the breakage of the rock or concrete (see Figure 7). The depth, diameter and location of the holes are carefully designed to achieve maximum crack propagation. The fractured rock or concrete can subsequently be removed by an excavator.

(d) **Mini-concrete cruncher**

The equipment comprises of a silenced electric powered compressor and pairs of hydraulically operated jaws which are suitable for concrete wall demolition works. For bigger capacity, the cruncher is positioned by hand using a wire rope (see Figure 8). According to manufacturer's data, the crushing force exerted by the jaws can be as much as 52 tonnes. The noise level for such crunching operation is far less than that for conventional breaking method by a jack hammer. The equipment is commercially available in various sizes.

(e) **Pile-cracker**

This commercially available equipment is specially made for breaking concrete piles without the emission of excessive noise. It consists of a number of hydraulically operated pistons which have pointed ends and operate in a radial direction. These pistons are extended towards the concrete pile, exerting a high compression force on the concrete and cause the concrete to crumble without damaging the reinforcement (see Figure 9).
(f) Cardox (Alternative to explosives)

The Cardox System uses the high pressure discharge of carbon dioxide gas to break down hard materials including rock and reinforced or mass concrete. The Cardox tubes, which consist of high tensile steel tubes filled with liquid carbon dioxide, are placed in holes drilled in the material to be broken. Upon application of an electrical charge, carbon dioxide is released at high pressure. The force exerted by this gas breaks up the material (see Figure 10).

(Courtesy of Allied Construction Equipment Ltd.)

Figure 5 Excavator-mounted hydraulic concrete crusher

(Courtesy of Nippon Pneumatic Mfg. Co. Ltd.)
Figure 6 Thermal lance set-up and operation
(Courtesy of Hong Kong Oxygen & Acetylene Co. Ltd.)

Figure 7 Non-explosive demolition method
(Courtesy of ONODA Corporation)
Figure 8  Mini-concrete cruncher
Figure 9  Pile-cracker
(Courtesy of Diaber)

Heavy weight to prevent cardox tube being expelled from the drilled hole

Figure 10  Typical example of CARDOX in operation
(Courtesy of Pikrose and Company Ltd.)
1.4 Sound levels for various types of concrete or rock breaking equipment

Sound levels for various types of concrete or rock breaking equipment are given in Table 1. Whenever possible, less noisy breaking equipment should be considered during the design and construction stage of a project. Information on sound measurements for some particular types of concrete or rock breaking equipment can be obtained from Reference 1 and 2.

Table 1—Comparison of sound levels for various types of concrete or rock breaking equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Sound level at 7 m from equipment</th>
<th>Weight of equipment under test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavator-mounted hydraulic/pneumatic breaker</td>
<td>65 70 75 80 85 90 95 100 dB(A)</td>
<td></td>
</tr>
<tr>
<td>Hand-held pneumatic breaker (standard)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-held pneumatic breaker (with exhaust silencer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-held pneumatic breaker (with exhaust silencer and muffled steel)</td>
<td></td>
<td>36 kg</td>
</tr>
<tr>
<td>Hand-held hydraulic breaker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal lance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mini-concrete cruncher</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Power units for various types of plant

2.1 Noise sources and noise control techniques

Most stationary plant (such as compressors, generators, concrete pumps and welding sets) and earth moving plant (such as excavators, bulldozers, loaders and dump trucks) are powered by internal combustion engines, the principal noise sources of which are described below (see Figure 11):
(a) Exhaust noise.

Exhaust noise is produced by the sudden release of gas into the exhaust system by the opening of the exhaust valves. The noise is transmitted along the pipe and radiated from the open end of the exhaust pipe. Leaks in the system and loose exhaust pipe mountings significantly increase noise levels.

The reduction of exhaust noise can be achieved by suitably designed and properly maintained exhaust silencers.

(b) Cooling system noise.

Cooling system noise is attributable to water pumps, belts, pulleys and cooling fans. The cooling fan is the major source of noise in the cooling system. Poor fan blade design and damaged fan blades may lead to significant levels of aerodynamic noise. Cooling system noise can be reduced by replacing the fan with an aerodynamic model, installing a contoured fan shroud or cowl with a close fan tip-to-shroud clearance, removing all obstructions such as bars and pipes from the inlet airflow, or adopting thermostatic control of the fan.

(c) Engine noise.

The radiated noise is associated with the combustion process and the mechanical noise from components such as gears, bearings and pistons.

The reduction of engine noise at source generally requires modification of the existing components. However, the transmission of engine noise can also be reduced by vibration isolation (see Figure 12) of individual components of the main engine structure, by providing specially designed partial or full acoustic enclosures for individual noise generating components and by applying damping material to vibrating panels. Partial or full enclosures can result in a reduction in the overall noise level of 10 and 25 dB(A) respectively (see Figure 13) (Ref. 6).
2.2 Silenced equipment

The noise emission from items of construction equipment using internal combustion engine power units varies between manufacturers. With regard to diesel or gasoline generators, silenced types are readily available and are manufactured with due consideration of noise reduction principles described in Section 2.1. The noise emission levels and the prices of the equipment vary between manufacturers. The difference in purchase price or rental cost between standard and silenced generators is around 10–16%. Information on silenced diesel or gasoline generators and power units can be obtained from several manufacturers, including those listed in Appendix D.

It should be noted that the panels or flaps of the machine enclosure should not be opened for ventilation purpose. This is not necessary (and may in fact result in overheating) and will significantly increase the level of noise being radiated.
3. PORTABLE AIR COMPRESSORS

3.1 Noise sources and noise control techniques

Noise from air compressors is mainly produced by the diesel engine, engine exhaust, cooling fan, blow-off valves and air intake. These noise sources can be controlled by using similar techniques described in Section 2.1. Asymmetric screw type and rotary compressors are widely used in the construction industry. They have many advantages in respect of their compactness, efficient operational characteristics, ease of maintenance as well as lower noise levels when compared with reciprocating type compressors. The use of electric compressors is encouraged whenever electric mains power is available because they are generally quieter and are more amenable to acoustic treatment than diesel engineed compressors.

3.2 Silenced equipment

Silenced compressors are readily available on the market. Their noise emission level is normally reduced by the application of sound absorbing linings to the casing, the use of mufflers and isolation of the engine and the compressor unit from the chassis by anti-vibration mounts. Super silenced type compressors are also commercially available. Most silenced compressors are manufactured to meet the European Economic Community directives or United States Environmental Protection Agency noise emission standards. Information on silenced type portable air compressors can be obtained from several manufacturers, including those listed in Appendix E.

It should be noted that the panels or flaps of the machine enclosure should not be opened for ventilation purpose. This is not necessary (and may in fact result in overheating) and will significantly increase the level of noise being radiated.

Table 2 shows a comparison for the difference in cost between standard compressors and silenced type compressors.

TABLE 2—COMPARISON OF COSTS FOR STANDARD AND SILENCED TYPE COMPRESSORS

<table>
<thead>
<tr>
<th>Type (2.5 m³/min to 17 m³/min)</th>
<th>Maximum noise level at 7 m from the compressor dB(A)</th>
<th>Average difference in cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>77 – 85</td>
<td>—</td>
</tr>
<tr>
<td>Silenced</td>
<td>75</td>
<td>20% 15%</td>
</tr>
<tr>
<td>Super silenced</td>
<td>70</td>
<td>40% 35%</td>
</tr>
</tbody>
</table>
4. NOISE CONTROL PRACTICE ON SITE

4.1 Selection of quiet equipment

To minimize the noise nuisance generated by construction works (which will, at the same time, reduce the exposure of workers to noise), it is important to use equipment which has been effectively silenced. Whenever possible, the quietest alternative should be used. For example, electric equipment should be preferred over diesel-powered types and hand-held hydraulic breakers over pneumatic breakers. In addition, it should be ensured that the equipment in use is the type most suitable for the job. Equipment which is greatly over-powered or, conversely, greatly under-powered should not be used.

4.2 Siting of equipment

Noisy equipment should always be sited as far away as possible from any noise-sensitive receiver such as residential buildings, schools or hospitals, etc. Advantage should be taken of the screening effect of any object nearby, such as water cooling tanks or temporary site offices.

4.3 Scheduling of work

To minimize the disturbance caused by noise it is often possible through careful scheduling of work to avoid carrying out noisy operations during sensitive hours (such as the teaching periods in schools and, in particular, school examination periods). In addition, noisy equipment should not be run for periods longer than necessary and should be switched off when not in use.

Whenever possible, the removal of a stockpile of earth or a topographical noise barrier should commence at the side far from any noise-sensitive receiver (see Figure 14), so that the earth itself can perform as a natural sound barrier which reduces the noise level and minimizes the length of disturbance to the receiver. Similar practice can be adopted for excavation works.

![Figure 14: Work schedule for removal of earth](image)
4.4 Use of acoustic barriers

An effective way of reducing noise is to locate noisy equipment behind purpose-built barriers. These can either be fabricated on site from readily available building materials or can be constructed from commercially available panels which are lined with sound absorbing material to achieve the maximum shielding effect. For maximum effectiveness, a barrier should be located as close as possible to either the noise source or receiver. Gaps and openings at joints in the barrier material should be avoided where possible. Barrier material of surface mass in excess of 7 Kg/m² is desirable to achieve the maximum screening effect. The length of a barrier should generally be at least five times greater than its height and the minimum height of a barrier should be such that no part of the noise source will be visible from the noise sensitive receiver being protected. An overall reduction of between 5 to 10 dB(A) can easily be achieved by these means. Figure 15 shows a type of sound absorbing panel and a noise barrier being erected to screen off the noise from a dump truck.

(Sound absorbing panel—Courtesy of ASAHI Glass Co. Ltd.)

(Noise barrier to screen off the noise from a dump truck)

Figure 15  Noise barrier
4.5 Use of acoustic machinery enclosures

Use of machine enclosures for stationary plant can achieve a noise reduction of up to 20 dB(A). The enclosure should cover the machine as fully as possible and the inside of it should be lined with sound absorbing material such as mineral wool, woodwool proprietary absorbent tiles or fibre-glass. Such enclosures can be constructed from a variety of readily available building materials and the maximum achievable noise reductions for some of these materials are shown in Table 3. Any opening in the enclosure will tend to compromise the noise reduction effect and should therefore be minimized.

Where forced ventilation is required for the enclosure of machines, the air intake and outlet of the enclosure should be fitted with suitably designed silencers or the enclosure should be carefully designed and arranged as shown in Figure 16.

Similar acoustic principles can be applied in the case of enclosures or partial enclosures for noisy work such as the use of hand-held pneumatic breakers (see Figure 17).

In the case of tunnel excavation works, the spoils or excavated materials should, whenever possible, be transported out through a totally enclosed conveyor belt system to avoid the use of noisy dump trucks. Preferably the spoil or excavated materials should be stockpiled in an acoustically treated mucking-out yard (see Figure 18) overnight and transported away in the day-time.

Information on sound absorbing materials and silencers can be obtained from several manufacturers, including those listed in Appendices F and G respectively.

Table 3—Sound insulation materials for machine enclosures

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (mm)</th>
<th>Surface Mass (Kg/m²)</th>
<th>Maximum achievable noise reduction dB(A)</th>
</tr>
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<tbody>
<tr>
<td>Brickwork</td>
<td>113</td>
<td>220</td>
<td>35 to 40</td>
</tr>
<tr>
<td>Compressed strawboard</td>
<td>50</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>Chipboard</td>
<td>18</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>13</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>Fibreboard</td>
<td>12</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Plywood</td>
<td>6</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>
4.6 Maintenance of equipment

Regular and effective maintenance by trained personnel will help to prolong the life of equipment as well as to reduce noise emission. Increases in plant noise are often indicative of imminent failure or breakdown. All air hoses should be checked regularly, moving parts should be lubricated, loose parts should be tightened and worn out components should be replaced. Sound reducing equipment should be checked regularly.

4.7 Site supervision

Unnecessary noise disturbance created from, for example, shouting, colliding of materials or striking of steel bars especially in noise sensitive periods can be avoided by close supervision of work on site. The site supervisor should take necessary precaution and ensure that the operations of all plant and work will not annoy any nearby noise sensitive receiver.

![Figure 16 Example of a machine enclosure](image1.png)

![Figure 17 Example of an enclosure for concrete breaking operations](image2.png)
Figure 18  Mucking-out yard for stockpile of spoil
PART II: NOISE FROM PILING OPERATIONS

5. NOISE FROM PILE DRIVING

5.1 Percussive piling methods

Conventional percussive piling methods involve the use of impact devices such as diesel, pneumatic or steam or drop hammers for driving piles into the ground. This almost inevitably gives rise to high noise levels, thus making this type of work one of the most significant sources of noise annoyance. The annoyance is the result of noise from the following two major sources (see Figure 19):

(a) Ringing and impact noise

The periodic impact of the steel ram on the pile helmet produces vibration within the impacting bodies as well as the pile itself. Ringing noise radiated from the surface of the pile is the dominant noise source from impact pile drivers. The radiated noise will depend on the exposed surface area—in general, the longer the length of the exposed pile the greater the level of the noise.

The use of concrete piles is preferable to steel piles in respect of noise emission since concrete is a material with high internal damping characteristics which result in a dull thud-like noise which is subjectively less annoying.

(b) Exhaust noise

Noise created by the release of pressurized gases from exhaust ports in the case of pneumatic, diesel and steam piling hammers can be significant. The exhausted gas is usually at a high residual pressure and produces high levels of broad-band noise.

In order to control the noise sources or propagation of the noise, various methods as described in Section 7 can be used. In addition, a number of quieter proprietary percussive piling methods as described in Sections 6.2 to 6.6 may be used. To reduce noise from driving steel sheet piles, the jacked piling method such as the Pilemaster as described in Section 6.7 has been developed overseas as an alternative to percussive piling methods. This method does not produce any impulsive noise.
5.2 Non-percussive piling methods

There are a number of piling methods commonly used in Hong Kong, which do not involve the use of impact pile driver, for example, use of vibratory hammers for driving steel piles, use of rotary boring or augering equipment for constructing bored piles, construction of hand-dug caissons, construction of diaphragm walls by excavation under bentonite and filling with concrete, etc. These methods are environmentally more acceptable than percussive piling because of the lower noise level and the less disturbing characteristics of the noise produced.

5.3 Sound levels for various piling methods

Table 4 shows typical values of the sound pressure levels (the equivalent continuous sound levels (Leq)) normalised to a distance of 15 metres for various piling methods operation. Whenever possible, lower operating sound level piling methods should be adopted.
**Table 4—Approximate sound pressure levels in dB(A) Leq at 15 metres for various piling methods**

<table>
<thead>
<tr>
<th>dB(A)</th>
<th>Piling method</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>* Double-acting hammer (pneumatic or steam) driving steel pile</td>
</tr>
<tr>
<td>95</td>
<td>* Diesel hammer driving steel pile</td>
</tr>
<tr>
<td></td>
<td>* Single acting hammer (pneumatic or steam) driving steel pile</td>
</tr>
<tr>
<td></td>
<td>* Hydraulic hammer driving steel pile</td>
</tr>
<tr>
<td></td>
<td>* Diesel hammer driving concrete pile</td>
</tr>
<tr>
<td>90</td>
<td>* Drop hammer driving steel pile</td>
</tr>
<tr>
<td>85</td>
<td>* Hydraulic hammer driving concrete pile</td>
</tr>
<tr>
<td></td>
<td>* BSP impulse pile driver</td>
</tr>
<tr>
<td>80</td>
<td>* Vibratory pile driver driving steel pile</td>
</tr>
<tr>
<td></td>
<td>* Drop hammer driving concrete pile</td>
</tr>
<tr>
<td></td>
<td>* Large-diameter bored pile (grab/chisel/oscillator)</td>
</tr>
<tr>
<td></td>
<td>* Bored pile by augering (with standard generators/compressors)</td>
</tr>
<tr>
<td>75</td>
<td>* Internal drop hammer (Franki Pile)</td>
</tr>
<tr>
<td>70</td>
<td>* Diaphragm wall (with standard crane)</td>
</tr>
<tr>
<td>65</td>
<td>* Diaphragm wall (with silenced or electric crane)</td>
</tr>
<tr>
<td></td>
<td>* Bored pile by augering (with silenced type diesel/generators/compressors)</td>
</tr>
<tr>
<td>Below</td>
<td>* Hush piling system</td>
</tr>
<tr>
<td></td>
<td>* Large-diameter bored pile (reverse-circulation drill method)</td>
</tr>
<tr>
<td></td>
<td>* Pilemaster</td>
</tr>
<tr>
<td></td>
<td>* Hand-dug caisson</td>
</tr>
</tbody>
</table>
6. QUIETER PROPRIETARY PILING METHODS

6.1 Introduction

The following sections describe a number of quieter proprietary piling methods which have been developed overseas to reduce noise from pile drivers. Some of them have the potential for application in Hong Kong while some have actually been used in Hong Kong. Details of the manufacturers can be found in Appendix H.

6.2 Internal Drop Hammers

Internal drop hammers are commonly used in Hong Kong for the construction of Franki piles. A hollow core steel tube is driven into the ground by the action of an internal drop hammer on an aggregate plug at the bottom of the tube. The internal drop hammer has the advantage that impact noise emanates near the bottom of the steel tube, which is under the ground after the first few hammer blows. Thus noise propagation is reduced by the circular enclosing wall of the tube and the damping from the soil into which the tube is driven. The predominant noise therefore comes from the piling base machine.

6.3 Hydraulic hammers

The principal features of a hydraulic hammer are illustrated in Figure 20.

Figure 20  Example of a hydraulic hammer  
(Courtesy of Uddcomb Sweden AB)
The basic principle is that the ram is raised to the desired stroke by hydraulic cylinders actuated by a hydraulic power unit that can, if necessary, be located separately from the hammer rig. At this point, the ram is caused to drop in a free-fall condition and imparts a powerful blow on the pile. The blow can be adjusted to suit the pile material by varying the ram stroke. The noise level (in Leq) for the operation of a hydraulic hammer generally depends on the drop height and rate of blows of hammer.

Hydraulic hammers are more effective than diesel hammers in relatively soft strata (standard penetration test N value less than 10) where the latter do not produce sufficient impact to generate the required explosion. Hydraulic hammers also have the advantage of causing no exhaust noise and no air pollutant emission.

6.4 **BSP Impulse Pile Driver**

BSP impulse pile drivers are manufactured by BSP International Foundations Ltd., U.K. (see Figure 21).

The driver is a compressed air-operated machine which utilizes an air cushion between the ram and the driving plate to avoid high noise level resulting from steel-to-steel impact. The effect of the air cushion is to reduce the peak forces thus also helping to minimize pile damage.

The cushion effect also renders a comparatively low maintenance cost of the impulse hammer. At the same time, such a cushion effect also reduces the noise level to an Leq of between 87 and 89 dB(A) at 15 metres. Except for hard driving conditions where the impulse hammer will not work effectively, the slightly higher cost of the hammer should not discourage its use and it has, in fact, already been used in Hong Kong.

![Figure 21 BSP ID17 Impulse Driver driving steel sheet piles](Courtesy of BSP International Foundations Ltd.)
6.5 *HUSH* Piling System

The ‘Hush’ piling rig which is operated by Bachy (U.K.) Ltd employs the principle of noise reduction by complete enclosure.

The enclosure takes the form of a long vertical rectangular box which fully encases the driving device and the pile or pair of piles being driven. The box acts as a leader to guide the hammer and pile and requires to be plumbed prior to each driving operation. A manually or hydraulically operated door on one side allows entry of the piles. The box is made up of a number of sections (each with a door) to accommodate varying pile lengths. The bottom door contains an inspection hatch which enables the operator to check progress during driving (see Figure 22). To screen the hammering noise, the walls of the box are constructed from five laminations of steel bonded by resilient plastic layers, giving an overall thickness of 16 mm. Gasketing is used around door apertures and it is only necessary to place sandbags around the base of the box when a high level of sound proofing is necessary. On a straight run, it is claimed that the rig can be operated within 500 mm of a boundary wall or other obstruction, measured from the back of piles.

The Hush H-rig, as the name suggests, is an adaptation for driving H piles quietly, although it will also accommodate concrete and tubular piles. The H-rig can handle piles up to 24 m in length and is smaller in area and lighter than the other rigs.

The piling rate of a Hush rig is comparable to that of conventional systems after a setting-up period to fix the driving gates. In the case of sheet piling, difficulties may occur in corners and junctions. Special corner and junction piles have to be manufactured on site to suit the local conditions.

The noise level (in Leq) from this type of equipment is around 70 dB(A) at 15 metres, making it one of the ‘less noisy’ piling methods.
6.6 Delmag Noise Reduction Mantle and the JASPP-type Sound-proof Cover

Diesel hammers are one of the noisiest types of percussive hammer. To offer solutions to this problem, ‘Delmag’ have manufactured the Noise Reduction Mantle (Grunzweig + Hartmann Muffler) and the Japanese Association for Steel Pipe Piles (JASPP) have developed the sound-proof cover JASPP-NBK and JASPP-NCK (see Figure 23).

This method consists of covering the pile and pile driver completely from top to bottom with a two-piece steel cover lined with sound absorbing material. The cover can reduce the noise level from the piling operation by more than 20 dB(A) under normal conditions and can abate the problems caused by exhaust fumes and oil spattering. A forced ventilation system is included to provide fresh air for the operation of the diesel hammer.

As the cover can be opened to an angle of 180 degrees, the pile can easily be checked for verticality whilst being driven. The bottom end of the cover can also be moved up and down, thus working around the pile driver and obtaining pile bearing capacity data are facilitated.
However, there are a number of disadvantages of using this type of equipment, including the time and manpower required for the setting up, adjustment and disassembly of the cover, and the fact that when the wind velocity is greater than 10 m/sec the pile driving operation must be stopped for safety reason.

An enclosure working on the same principle has been designed and erected locally for one of the major projects in Hong Kong. In this case the noise from a diesel hammer driving H piles was reduced by 15 dB(A).

6.7 SERF Pilemaster

The Pilemaster employs a hydraulic machine which drives and extracts steel sheet piles with little noise and vibration. It consists of a power pack mounted on a steel crosshead containing eight hydraulic rams (see Figure 24). Each ram bears on top of a pile. Any two rams are driven downwards to their full 750 mm stroke, pushing the attached piles into the ground. This operation is repeated with each pair of piles in turn until all eight piles have been driven 750 mm. The machine is then lowered and the cycle is repeated.

The driving rate of the Pilemaster is comparable to conventional system when the machine operates in clay soils of cohesive strength up to about 250 kN/m² and in silts and fine sands having standard penetration test N value less than 15. It will not operate in gravels or medium and coarse sands.
The noise level measured in Leq from this type of equipment at 15 metres is between 65 and 67 dB(A), making it one of the ‘less noisy’ piling methods.

Figure 24 SERF Pilemaster Hydraulic Jack (Courtesy of SERF Ltd.)

7. CONTROL OF PILING NOISE

7.1 Adoption of quieter piling methods

Where practicable, non-percussive piling methods such as bore piles by augering or other methods as illustrated in Section 5 should be used. Alternatively other quieter piling methods as illustrated in Section 6 can be used to reduce the noise from pile drivers. It is important to ensure that all ancillary equipment used for the piling works (such as cranes, pumps, air compressors and diesel generators) are effectively silenced.

7.2 Use of resilient packing and dolly

In the case of percussive piling, the head of the pile should be protected by a helmet fitted with resilient packing over the top of the pile and a dolly which cushions the blow of the hammer (see Figure 25). The dolly and packing should be inspected regularly and maintained in good mechanical condition.

7.3 Shrouding

When a noisy piling method cannot be avoided, consideration should be given to enclosing the complete pile and the pile driver. The shroud should consist of a robust framework fitted with an acoustically designed cladding (see Figure 26) or acoustic panels which are available on the market. Alternatively,
flexible thick vinyl curtain can be suspended to enclose the whole length of the exposed pile and pile driver (see Figure 27). In the design and construction of a shroud, the principles described in Section 6.5 and 6.6 above should be followed. Information on acoustic panels and vinyl curtains can be obtained from several manufacturers, including those listed in Appendix F.

7.4 Damping of steel pile

Steel pile columns can be treated with damping compounds to reduce the ringing noise. The damping compound can be applied to the surface of the pile by painting or spraying. Information on damping materials can be obtained from several manufacturers, including those listed in Appendix F.

7.5 Scheduling of work

To minimize the disturbance caused by noise it is often possible through careful scheduling of work to avoid carrying out noisy operations during sensitive hours (such as the teaching periods in schools and, in particular, school examination periods). In addition, noisy equipment should not be run for period longer than necessary and should be switched off when not in use.

7.6 Maintenance

Regular servicing and maintenance of the piling equipment by trained personnel is essential and will help to reduce noise and prolong the useful life of equipment.

Figure 25  Resilient packing and dolly
Figure 26  Acoustic shroud for pile driving

Figure 27  Flexible vinyl curtain for pile driving
(Courtesy of Peabody Noise Control)
8. GENERAL CONSIDERATIONS

The inclusion of construction noise control specifications into tender and contract conditions has a number of merits, it will—

(a) allow all tenderers to take the cost of noise control into account;  
(b) minimize contractual disputes on the responsibility to provide noise abatement measures;  
(c) encourage thoughtful and economical planning of works, and will avoid expensive retrofitting and delay;  
(d) result in a better corporate image; and  
(e) as a result of quieter operations, place the contractors in a better position with respect to the application of a Construction Noise Permit.

These specifications, samples of which are provided in Table 5 of Section 9, generally fall into the following categories:—

(a) use of silenced/quiet equipment (See C1 to C2);  
(b) adoption of quiet alternative techniques (See C3 to C4);  
(c) erection of noise reducing devices such as silencers, barriers or enclosures (See C5);  
(d) imposition of time restrictions (See C6 to C7);  
(e) maintenance of equipment (See C8);  
(f) specification of noise level limits (See C9 to C10);  
(g) control of unnecessary noise (See C11);  
(h) compliance with legislation (See C12) and  
(i) enforcement of contract clauses (See C13).

9. SPECIFICATIONS FOR TENDER AND CONTRACT

The sample specifications provided in this section are meant to illustrate how noise control specifications can be set. Readers are encouraged to incorporate and/or modify them to suit their specific needs.

For the purpose of clarity, these specifications are tabulated against certain objectives to be achieved through the incorporation of the particular specifications (See Table 5).
<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Objective</th>
<th>Sample Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>To request submission of equipment information</td>
<td>&quot;The tenderer shall submit information on the types and models of silenced equipment and acoustic treatments for unsilenced equipment he intends to use as described in the Tender Document. Failure to provide such information may lead to disqualification of his tender submission.&quot;</td>
</tr>
<tr>
<td>C2</td>
<td>To use silenced hand-held breakers/generators/compressors</td>
<td>&quot;All hand-held breakers*/generators*/portable air compressors* used on site shall be of a silenced type as listed in Schedule I, or their equivalent approved by the (e.g. Engineer).&quot; (See note below)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: Please refer to Appendices A, B, D &amp; E of this booklet for examples of Schedule I.</td>
</tr>
<tr>
<td>C3</td>
<td>To specify the use of quiet concrete breaking techniques (especially for site with adjoining noise sensitive receivers)</td>
<td>&quot;No rock breaking equipment shall be used on site other than the use of concrete breaking techniques as listed in Schedule II, or their equivalent approved by the (e.g. Engineer).&quot; (See note below)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: Please refer to Section 1.3 of this booklet for examples of Schedule II on alternative concrete or rock breaking techniques.</td>
</tr>
<tr>
<td>C4</td>
<td>To use quiet piling techniques</td>
<td>&quot;All pile driving equipment used on site shall be of the type as listed in the Schedule III, or equivalent approved by the (e.g. Engineer).&quot; (See note below)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: Please refer to Table 4 of this booklet for examples of Schedule III. A piling method having sound pressure level of 90 dB(A) or less at a reference distance of 15 metres should be adopted.</td>
</tr>
</tbody>
</table>

* The reader can select the appropriate word or use all of them where applicable.
<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Objective</th>
<th>Sample Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>To install noise reduction measures</td>
<td>&quot;The Contractor shall erect or use effective sound reduction installations by means of silencers, mufflers, acoustic linings or shields, acoustic sheds or screens for equipment as considered appropriate by the (e.g. Engineer).&quot; (See note below)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: Please refer to Section 4 of this Booklet for examples of screens, enclosures, etc.</td>
</tr>
<tr>
<td>C6</td>
<td>To specify working hours/avoid creating certain noisy operations at night or during school examination periods</td>
<td>&quot;No concrete breaking*/excavation*/rock crushing*/piling* shall be carried out on site between the hours __________ .&quot; (See note below)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: Time restrictions to avoid the use of such equipment can be imposed with reference to the operation hours of any nearby noise sensitive receivers such as medical clinics, educational institutions (especially during examination periods), court of law, etc.</td>
</tr>
<tr>
<td>C7</td>
<td>To specify the minimum working hours for piling work</td>
<td>&quot;The Contractor shall evaluate the permitted hours of his percussive piling operation in accordance with the Technical Memorandum on Noise from Percussive Piling to ensure that the type of piling equipment adopted on site would be permitted to operate for 5 hours*/12 hours* per day&quot;</td>
</tr>
<tr>
<td>C8</td>
<td>To avoid noise caused by poor maintenance</td>
<td>&quot;The Contractor shall take all reasonable precautions in the opinion of the (e.g. Engineer), to maintain all plant and silencing equipment in good condition in order to minimize the noise emission during construction works. The cost of maintaining all plant shall be deemed to be included in the relevant contract rates.&quot;</td>
</tr>
</tbody>
</table>

* The reader can select the appropriate word or use all of them where applicable.
<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Objective</th>
<th>Sample Specifications</th>
</tr>
</thead>
</table>
| C9        | To impose noise level limit to protect a specific noise sensitive receiver | The Contractor shall ensure that the noise level from the equipment used on site or his construction process when measured at 1 metre from the closest external facade of the (e.g. xx Hospital, yy School) during any 5-minute period shall not exceed an equivalent continuous sound level (Leq) of _______ dB(A). The construction operation shall stop in the event of non-compliance with this clause. It shall not recommence without the consent of (e.g. Engineer).” (See note below)  
Note: A noise level limit should be adopted with reference to Acceptable Noise Levels in the Technical Memorandum on Noise from Construction Work other than Percussive Piling taking also into account the specific local noise climate and/or noise sensitive receiver. |
| C10       | To provide sound level meter                                               | “The Contractor shall provide an approved sound level meter to IEC804: 1985 or 651: 1979 (Type 1) and calibrator for the exclusive use of the (e.g. Engineer) at any time during the Contract. The Contractor shall, when required, maintain, repair and replace the meter. The meter shall revert to the Contractor at the end of the Contract.” (See note below).  
Note: Information on general calibration procedures for sound level meters can be obtained from Reference 4 or 5. |
<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Objective</th>
<th>Sample Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>C11</td>
<td>To control noisy activities</td>
<td>&quot;The Contractor shall take all such necessary measures as may be required by and to the satisfaction of (e.g. Engineer) to ensure that the operation of all plant and construction processes on site will not cause any unnecessary and excessive noise which disturbs or annoys any nearby noise sensitive receivers.&quot;</td>
</tr>
<tr>
<td>C12</td>
<td>To comply with environmental protection legislation</td>
<td>&quot;The Contractor shall comply with and observe all ordinances, bye-laws, regulations and rules for the time being in force in Hong Kong governing the control of any form of pollution, whether aerial or otherwise, and the protection of the environment.&quot;</td>
</tr>
<tr>
<td>C13</td>
<td>To enforce the Contract Clause on noise control</td>
<td>&quot;The Contractor shall stop the construction process or operation of equipment in the event of non-compliance of the clauses in this contract. Any stoppage of work which may be ordered by the (e.g. Engineer) on account of failure to comply with these clauses will not entitle the Contractor to any extension of time for completion or any compensation whatsoever.&quot;</td>
</tr>
</tbody>
</table>
GLOSSARY OF ACOUSTIC TERMINOLOGY

Noise — Noise is any sound which at the time of reception is unwanted or disturbing.

Decibel, dB — A dimensionless unit used to express logarithmically the ratio of one sound power or pressure to a reference value.

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. (Using light as an analogy, it is equivalent to the power of a light bulb expressed in watts).

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. (Using light as an analogy, it is equivalent to the brightness or intensity of light at a particular point).

A-weighted Decibel, dB(A) — The A-weighted decibel is a commonly used unit for measuring environmental noise taking into account the way human ear responds to noise.

The Equivalent Continuous Noise Level, Leq — The level of a constant sound having the same sound energy as an actual time-varying sound over a given period.

Frequency — The number of repetitive variations of sound pressure per unit of time. Frequency is measured in Hertz (Hz), i.e. cycles per second. It is the characteristics of a sound which influences our perception of it as high or low in pitch.
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Quieter demolition techniques.
Building Research Establishment, Department of the Environment,
Paper No. CP 66/75 (July 1975).

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A review of noise-reduced construction plant.
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Paper No. CP 68/78 (October 1976).

3. CAGI-PNEUROP Test Code for the measurement of sound from pneumatic equipment.
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Department of Transportation of the U.S.A.,

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Noise Control Engineering Journal,
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British Standards Institution.

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CIRIA Report 64.
APPENDICES

Information on Commercially Available Quiet Construction Equipment, Noise Control Products and Quiet Concrete Breaking Techniques

There are several businesses engaged in the manufacturing/supplying/offering of quiet construction equipment, noise control materials and quiet concrete breaking techniques for the construction industries. Published literature may be obtained from these manufacturers or their sales representatives relating to:

(a) Product information
(b) Performance test data
(c) Suggestions for applications
(d) Case histories
(e) General technical information
(f) Cost information
APPLENDIX A

Silenced Type Hand-held Pneumatic Breaker

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Brand name and model</th>
<th>Equipment size (kg)</th>
<th>Air consumption rate (m³/min)</th>
<th>Address of local authorized agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlas Copco MCT AB</td>
<td>TEX 11DCS, TEX 22S, TEX 32S, TEX 42S</td>
<td>25-43</td>
<td>1.5-2.0</td>
<td>Atlas Copco (HK) Ltd. 227-229 Wai Yip Street, 1st Floor, Kwun Tong, Kowloon. Tel.: 3-413273</td>
</tr>
<tr>
<td>CompAir Holman Ltd.</td>
<td>Zitec 14, Zitec 20, Zitec 27</td>
<td>14-38.7</td>
<td>1.2-2.0</td>
<td>C. Crossfield &amp; Co. Ltd. Room 1303-1306, Hollywood Plaza, 610 Nathan Road, Kowloon. Tel.: 3-851031</td>
</tr>
<tr>
<td>Ingersoll-Rand Co.</td>
<td>BR 20S, BR 30S, BR 40S</td>
<td>23-37</td>
<td>1.7-2.0</td>
<td>Sime Darby Hong Kong Ltd. Construction Equipment Division, The China Engineer Ltd. 2-12 Lung Ting Road, Tsing Lung Tau, Tsuen Wan. Tel.: 0-4910621</td>
</tr>
</tbody>
</table>
### APPENDIX B

**Hand-held Hydraulic Breaker**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Brand name and model</th>
<th>Equipment size (kg)</th>
<th>Oil flow rate (l/min)</th>
<th>Address of local authorized agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>JCB Hydrapower</td>
<td>JCB</td>
<td>25</td>
<td>20</td>
<td>Heavy Equipment International Ltd. 12th Floor, Somerset House, Taikoo Trading Estate, 28 Tong Chong Street, Quarry Bay, Hong Kong. Tel.: 5-8118398</td>
</tr>
<tr>
<td>Maruzen Rogyo Co. Ltd.</td>
<td>Maruzen MHB 16 MHB 25 MHB 32</td>
<td>16-32</td>
<td>20-25</td>
<td>Retco Mechanical Co. 2A Dundas Street, Ground Floor, Kowloon. Tel.: 3-320735</td>
</tr>
<tr>
<td>Stanley Hydraulic Tools</td>
<td>Stanley BR 37 BR 45 BR 67 BR 87</td>
<td>17-36</td>
<td>26-34</td>
<td>The Stanley Works (Hong Kong) Ltd. Room 1433, Central Building, Pedder Street, Hong Kong Tel.: 5-262983</td>
</tr>
</tbody>
</table>
APPENDIX C

Quieter Concrete Breaking Equipment and Techniques

Sound Proof Hammer Bracket

1. Krupp Industrietechnik GmbH
   Postfach 102144, Helenestraße 149, D-4300 Essen 1,
   Federal Republic of Germany. Faxline: 0201-3140501
   Agent in Hong Kong: Rokhammers
   Room 1233, Star House, 3 Salisbury Road,
   Tsim Sha Tsui, Kowloon. Tel.: 3-7301001

Excavator-Mounted Concrete Crusher

2. Allied Construction Equipment Ltd.
   Dowsetts Lane, Ramsden Heath, Billericay, Essex, CM11 1JQ, England,
   U.K. Faxline: 0268-71091
   Agent in Hong Kong: Not available

3. Holemasters Concrete Cutting & Drilling Service
   Unit G3, Europa Trading Estate, Stoneclough Road, Radcliffe, Manchester,
   M26 9EH, U.K. Faxline: 0204-861226
   Agent in Hong Kong: Not available

   No. 11-5, 4-chome, Kamiji, Higashinari-Ku, Osaka, Japan. Telex: 529-6566
   Agent in Hong Kong: Well-Joint Engineering Ltd.
   Room 1005, Shing Chuen Industrial Building,
   25-27 Shing Wan Road, Tai Wai, Sha Tin.
   Tel.: 0-6977223

5. Okada Aiyon Corp.
   4-1-18, Kaigan-dori, Minato-ku, Osaka 552, Japan. Faxline: 06-576-1260
   Agent in Hong Kong: Retco Mechanical Co.
   2A Dundas Street, Ground Floor, Kowloon.
   Tel.: 3-320735

Thermal Lance

6. Hong Kong Oxygen & Acetylene Co., Ltd.
   DD234, Lot 317, Hang Hau, Clearwater Bay, Kowloon. Tel.: 3-7197100

Non-explosive Demolition Agent

7. Onoda Corporation
   7th Floor, Okachimachi CY Building, No. 15-14, 5-chome, Ueno,
   Taito-ku, Tokyo, Japan, 110. Faxline: 03837-0726
   Agent in Hong Kong: Mitsui & Co. (Hong Kong) Ltd.
   25th-26th Floor, Far East Finance Centre,
   16 Harcourt Road, Hong Kong. Tel.: 5-8238777
Mini-concrete Cruncher

8. Holemasters Concrete Cutting & Drilling Service
   Unit G3, Europa Trading Estate, Stoneyclough Road, Radcliffe, Manchester, M26 9EH, U.K. Faxline: 0204-861226
   Agent in Hong Kong: Not available

   Victoria Way Burgess Hill, West Sussex, England, RH15 9NF, U.K.
   Faxline: 0444-870297
   Agent in Hong Kong: WACO International Formwork & Access Systems Ltd.
   12th Floor, Tai Po Commercial Centre,
   152-172 Kwong Fuk Road, Tai Po,
   New Territories. Tel.: 0-6539328

10. Specialist Services (Cutting and Drilling) Ltd.
    Specialist House, 52-54 Northern Road, Cosham, Portsmouth, England, PO6 3DP, U.K. Faxline: 0705-379682
    Agent in Hong Kong: Not available

11. Diaber Ag.
    Diamantwerkzeugfabrik Ch-8700 Kusnacht-Zurich,
    Telex: 825780 DIAB CH
    Agent in Hong Kong: Not available

Pile Cracker

12. Diaber Ag.
    Diamantwerkzeugfabrik Ch-8700 Kusnacht-Zurich,
    Telex: 825780 DIAB CH
    Agent in Hong Kong: Not available

Cardox System

13. Pikrose and Company Ltd.
    Delta Works, Delta Road, Audenshaw, Manchester, M34 5HS.
    Telex: 0204-667488
    Agent in Hong Kong: Leighton Contractors (Asia) Ltd.
    49th Floor, Hopewell Centre,
    183 Queen's Road East, Hong Kong.
    Tel.: 5-823111.
## APPENDIX D

### Silenced Type Diesel/Gasoline Generator and Power Unit

<table>
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<tr>
<th>Manufacturer</th>
<th>Brand name and model</th>
<th>Output power in kVA at 50 Hz prime load</th>
<th>Address of local authorized agent</th>
</tr>
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<tbody>
<tr>
<td>Denyo Co. Ltd.</td>
<td>Denyo</td>
<td>12.5 – 650 (Diesel generator)</td>
<td>Reliance Motors Ltd.</td>
</tr>
<tr>
<td></td>
<td>DCA type:—</td>
<td></td>
<td>Power Product Department,</td>
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<tr>
<td></td>
<td>15SS-N, 90SPH</td>
<td></td>
<td>3rd Floor, 154-158</td>
</tr>
<tr>
<td></td>
<td>22SPN, 125SPK</td>
<td></td>
<td>Prince Edward Road West,</td>
</tr>
<tr>
<td></td>
<td>25SPM, 220SSA-K</td>
<td></td>
<td>Kowloon.</td>
</tr>
<tr>
<td></td>
<td>45SPH, 250SSA-C</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>45SPH, 380SSA-M</td>
<td></td>
<td></td>
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<td>60SPH, 600SSA-K</td>
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<tr>
<td></td>
<td>75SPH, 750SSA-M</td>
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<tr>
<td>Honda Motor Co. Ltd.</td>
<td>Honda</td>
<td>0.45 – 5.0 (Gasoline generator)</td>
<td>Reliance Motors Ltd.</td>
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<tr>
<td></td>
<td>EX 650</td>
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<td>Power Product Department,</td>
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<tr>
<td></td>
<td>EX 2200</td>
<td></td>
<td>3rd Floor, 154-158</td>
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<tr>
<td></td>
<td>EX 3000</td>
<td></td>
<td>Prince Edward Road West,</td>
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<tr>
<td></td>
<td>EX 3000S</td>
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<tr>
<td></td>
<td>EX 3300S</td>
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<td></td>
<td>EX 4000S</td>
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<td>EX 4500S</td>
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<td></td>
<td>EM 650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hatz Motorenfabrik GmbH</td>
<td>Hatz</td>
<td>9.5 – 51 (Diesel power unit)</td>
<td>HD Engineering Ltd.</td>
</tr>
<tr>
<td></td>
<td>L 31C</td>
<td></td>
<td>Room 1233, Star House,</td>
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<tr>
<td></td>
<td>L 40C</td>
<td></td>
<td>3 Salisbury Road, Tsim Sha Tsui,</td>
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<td></td>
<td></td>
<td>Kowloon.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tel.: 3-7301001</td>
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**Silenced Type Portable Air Compressor**

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<tr>
<th>Manufacturer</th>
<th>Brand name and model</th>
<th>Air delivery ((m^3/min)) at working pressure of 7 kg/cm(^2) (100 p.s.i.)</th>
<th>Address of local authorized agent</th>
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<tr>
<td>Atlas Copco MCT AB</td>
<td>Atlas Copco XAS 60Dd XAS 85Dd XAS 125Dd XAS 175Dd XAS 280Dd XAS 350Dd</td>
<td>1.8 – 25.5</td>
<td>Atlas Copco (HK) Ltd. 227-229 Wai Yip Street, 1st Floor, Kwan Tong, Kowloon, Tel.: 3-413213</td>
</tr>
<tr>
<td>CompAir Holman Ltd.</td>
<td>CompAir Zitair 70-9 Zitair 85, 600-100S Zitair 100, 750-100S Zitair 125 Zitair 150 Zitair 175 Zitair 250 Zitair 400-125</td>
<td>2.0 – 34.0</td>
<td>C. Crossfield &amp; Co. Ltd. Room 1303-1306, Hollywood Plaza, 610 Nathan Road, Kowloon, Tel.: 3-851031</td>
</tr>
<tr>
<td>Denyo Co. Ltd.</td>
<td>Denyo DPS-90SS DPS-130SS DPS-175SS DPS-250SS DPS-370SS DPS-600SS</td>
<td>2.5 – 17.0</td>
<td>Reliance Motors Ltd. Power Product Department 3rd Floor, 154-158 Prince Edward Road West, Kowloon, Tel.: 3-975111</td>
</tr>
<tr>
<td>Ingersoll-Rand Co.</td>
<td>Ingersoll-Rand Whisperized types.— P-100-W-W P-100-W-D P-175-W-W P-175-W-D P-185-W-SD</td>
<td>2.4 – 45.3</td>
<td>Sime Darby Hong Kong Ltd. Construction Equipment Division, The China Engineer Ltd. 2-12 Lung Tung Road, Tsing Lung Tau, Tuen Wan, Tel.: 0-4910621</td>
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### Noise Control Materials

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<th>Manufacturer</th>
<th>Brand name and product</th>
<th>Address of local authorized agent</th>
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<tr>
<td>ASAHI Glass Co., Ltd.</td>
<td>Glasron</td>
<td>Oxprime Ltd.</td>
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<tr>
<td></td>
<td>Noise control panels.</td>
<td>2nd Floor, Henfa Commercial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building, 348–350 Lockhart Road,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hong Kong.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tel.: 5-8910848</td>
</tr>
<tr>
<td>Industrial Acoustics Co. Hong Kong Ltd.</td>
<td>IAC</td>
<td>Industrial Acoustics Co. Ltd.</td>
</tr>
<tr>
<td></td>
<td>Acoustic panel, barrier, enclosure.</td>
<td>Room 2410, Hopewell Centre,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>183 Queen’s Road East,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hong Kong.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tel.: 5-8611891</td>
</tr>
<tr>
<td>Industrial Noise Control</td>
<td>Decibar</td>
<td>Cemac (HK) Ltd.</td>
</tr>
<tr>
<td></td>
<td>Acoustic foam, protective facings, combined absorbing and damping materials for barrier.</td>
<td>3rd Floor, McDonald’s Building,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48 Yee Wo Street, Causeway Bay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hong Kong.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tel.: 5-770636</td>
</tr>
<tr>
<td>Peabody Noise Control</td>
<td>Kinetics</td>
<td>Builders Federal (HK) Ltd.</td>
</tr>
<tr>
<td></td>
<td>Acoustic foam, loaded vinyl, barriers, baffles damping compound, acoustical composites, vibration isolators, acoustic enclosure.</td>
<td>6th Floor, Printing House,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 Duddell Street, Hong Kong.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tel.: 5-251169</td>
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</tbody>
</table>
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## Silencers

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Brand name</th>
<th>Address of local authorized agent</th>
</tr>
</thead>
</table>
| A Boët                   | A Boët     | Federation of French Mechanical Industries  
18E, Ho Lee Commercial Building,  
38-40 D’Aguilar Street, Central,  
Hong Kong.  
Tel.: 5-257570 |
| Industrial Acoustics Co. | IAC        | Industrial Acoustics Co. Ltd.  
Room 2410, Hopewell Centre,  
183 Queen’s Road East,  
Hong Kong.  
Tel.: 5-8611891 |
| NAP (Aust) pty. Ltd.     | NAP Silentflo | Cemac (HK) Ltd.  
3rd Floor, McDonald’s Building,  
48 Yee Wo Street, Causeway Bay,  
Hong Kong.  
Tel.: 5-770836 |
| Sound Attenuators Ltd.   | SAL        | Builders Federal (HK) Ltd.  
6th Floor, Printing House,  
6 Duddell Street, Hong Kong.  
Tel.: 5-251169 |
APPENDIX H

Quieter Proprietary Piling Methods

Internal Drop Hammer

1. Agent in Hong Kong: Franki Kier Ltd.
   2nd-3rd Floor, Franki Centre, 320 Junction Road, Kowloon Tong, Kowloon. Tel.: 3–398222

Hydraulic Hammer

2. BSP International Foundations Ltd.
   Claydon Industrial Park, Gipping Road, Gt. Blakenham, Ipswich, Suffolk, IP6 0JD, England, U.K. Faxline: 0473–832019
   Agent in Hong Kong: EKPAC Equipment Ltd.
   26th Floor, Sungib Industrial Centre, 53 Wong Chuk Hang Road, Aberdeen, Hong Kong. Tel.: 5–555555

3. DELMAG-Maschinenfabrik, Reinhold Dornfeld GmbH + Co.
   D-7300 Esslingen (West-Germany), Max-Planck. Straße, Postfach 190.
   Faxline: 0711–3950111
   Agent in Hong Kong: FEDCO
   Room 1233, Star House, 3 Salisbury Road, Tsim Sha Tsui, Kowloon. Tel.: 3–7301001

4. Nippon Sharyo Ltd.
   Kaisei Bldg. 13–2, Nihonbashi Kabuto-cho, Chuo-ku, Tokyo 103, Japan.
   Faxline: 03–669–0238
   Agent in Hong Kong: Not available

5. Uddcomb Sweden AB
   Box 523, S-371 23 Karlskrona, Sweden. Faxline No: 0455–262–46
   Agent in Hong Kong: Avis Engineering Equipment Ltd.
   P.O. Box No. 80396, Cheung Sha Wan Post Office. Tel.: 3–935733

Impulse Pile Driver

6. BSP International Foundations Ltd.
   Claydon Industrial Park, Gipping Road, Gt. Blakenham, Ipswich, Suffolk, IP6 0JD, England, U.K. Faxline: 0473–832019
   Agent in Hong Kong: EKPAC Equipment Ltd.
   26th Floor, Sungib Industrial Centre, 53 Wong Chuk Hang Road, Aberdeen, Hong Kong. Tel.: 5–555555
Pile Driver with Enclosure

7. Bachy (UK) Ltd.
   Foundation Court, Godalming Business Centre, Catteshall Lane,
   Godalming, Surrey, GU7 1XW, U.K. Faxline: 04868-7021
   Agent in Hong Kong: Not available

8. DELMAG-Maschinenfabrik, Reinhold Dornfeld GmbH + Co.
   D-7300 Esslingen (West-Germany), Max-Planck. Straße, Postfach 190.
   Faxline: 0711-3950111
   Agent in Hong Kong: FEDCO
       Room 1233, Star House, 3 Salisbury Road,
       Tsim Sha Tsui, Kowloon. Tel.: 3-7301001

9. Japanese Association for Steel Pipe Piles
   3-2-10, Nihonbashi-Kayaba-cho, Chuo-ku, Tokyo 103, Japan.
   Faxline: Tokyo 669-1685
   Agent in Hong Kong: Not available

Pilemaster

10. Serf Ltd.
    P.O. Box 35, Oldham, Lancs, England, U.K. Faxline: 667473
    Agent in Hong Kong: Not available
ADDITIONAL INFORMATION

The information contained in this booklet will be updated and expanded from time to time. Manufacturers or suppliers of quiet construction equipment are encouraged to provide additional relevant information for inclusion in future editions of the booklet. Please fill in the form below and send it, together with relevant catalogues, specifications and other information, to the Environmental Protection Department of the Hong Kong Government.

For further enquiries, please contact the Noise Policy Group at telephone number 5-8351124.

To: Principal Environmental Protection Officer
Noise Policy Group
Environmental Protection Department
27th Floor, Southorn Centre,
130 Hennessy Road,
Wan Chai,
Hong Kong.

INFORMATION ON QUIET CONSTRUCTION EQUIPMENT

We are manufacturers/suppliers of quiet construction equipment and wish to provide you with the enclosed catalogues/specifications of our products for your consideration for inclusion in future editions of the booklet ‘A PRACTICAL GUIDE FOR THE REDUCTION OF NOISE FROM CONSTRUCTION WORKS’.

Name of company: ________________________________________________

Type of equipment: ______________________________________________

Name of person to contact: ________________________________________

Position: _________________________________________________________

Address: _________________________________________________________

Telephone: _______________ Faxline: ________________________________
消減建築噪音實用指南

環境保護署
噪音政策組

香港灣仔軒尼詩道130號
修頓中心27樓

一九八九年七月
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導言

本小冊子旨在提供有關低噪音的建築設備資料，及介紹各種有助於減輕建築工程噪音的施工辦法。其內容將會不時增添及作出最新修訂。因此，讀者如能提供其他有關資料本署定當樂意接受。

本小冊子共分為三個部分：
第 I 部：一般建築機動設備發出的噪音
第 II 部：打樁工程發出的噪音
第 III 部：管制建築噪音的合約規格和條款

第 I 及 II 部分是為承建商及其他人士對聲學有少許認識而編寫。第 I 部說明各種常用的建築機動設備所採用的減音方法。第 II 部則討論打樁工程所發出的噪音，當中並介紹製造商及研究機構就該等設備而提供的噪音數據，以供讀者參閱及比較，從而選擇那些發出較少噪音的機動設備用以進行建築工程。第 I 及 II 部所述的低噪音型設備均可在本港或海外購得。

第 III 部列舉一些控制噪音的合約規格和條款的實例，兩者均可列入建築工程合約內。將此等條款列入合約是一項有用的預防措施，俾在施工期間，可避免加添那些效益不符理想，兼且費用昂貴的控制噪音工程。

本小冊子所載有關某公司或產品的任何資料或所提及的任何特定產品的牌子名稱，均絕非表示香港政府推薦或認可此種產品。該等資料或所提及的牌子名稱僅作示範說明之用，冊子內沒有列入或提及的任何產品或公司均不可解釋作爲香港政府不同意採用論。冊子內所述的產品數據業經有關的製造商或其認可的代理商或代表證明屬實。然而，冊子內文對任何產品所作的介紹，不應解釋作爲香港政府對該等產品的保證。讀者應就冊子內所指的任何產品向獨立的專業人士尋求該產品之操作、使用、裝置、保養等方面的專業或技術指導。
第Ⅰ部：一般建築機動設備發出的噪音

1. 混凝土或石頭破碎機設備
1.1 噪音源及控制噪音的技術

混凝土或石頭通常是以手提式或裝在挖土機上的破碎機，予以破碎。如以氧氣破碎機將之破碎，噪音源主要來自三方面，詳情見於圖1。每一來源的相對強度須視乎設備所屬類別而定。值得注意的是：倘若只消除其中一處來源而對其他來源置之不理，則整體的噪音聲級將不會作顯著的減輕。

![圖1 氣動破碎機的噪音源](image-url)

主要的噪音源計有：

(a) 排氣噪音

排氣噪音是因氣動破碎機突然釋放出空氣而產生。此種噪音可予以減低，辦法是裝上一具隔音罩，將排出的空氣通過一條較長的排氣通道排放，降低其排氣速度，從而減低噪音的脈衝特性。一般而言，使用隔音罩最高可將排氣噪音減低十五分貝(A)（見圖2）
(b) 從機身發出的噪音

機身發出的噪音是來自氣缸封套及前端封套，是活塞撞擊鐵砧及錘身所造成的。

部分製造商附設的隔音罩，將氣缸全部圈封。該等隔音罩可減低機身發出噪音高達6分貝(A)（見圖2）。用帆布或其他布料包裹機身，是不能將噪音的幅度減低。

(c) 鑽頭發出如鐘鳴的噪音

鋼鑽頭與堅硬表面撞擊，因而引起震動，產生顯著如鐘鳴的高頻率噪音。

減輕此種像鐘鳴的高頻率噪音辦法，是在鑽頭加上一層抑制性的阻尼減震材料。市面上製造的阻尼減震器備有鋼環箍，用以固定阻尼減震材料及避免磨損（見圖3）。此種減音方法可將噪音減低約3分貝(A)，並可減輕聽覺上的滋擾程度。

圖2 用以減輕排氣噪音及從機身發出噪音的隔音罩

(蒙 Ingorsoli – Rand Co. 特許轉載此圖)
1.2 低噪音型機動設備

(a) 手提型氣動破碎機

上文第1.1節所述配備有隔音罩及阻尼（減震）箍的手提型氣動破碎機，在市面上有售。該等破碎機大部分符合歐洲共同體的法規或美國環境保護局所定的噪音排放標準。與標準型破碎機比較，低噪音型破碎機的售價約高出百分之六。然而，由於排氣隔音罩引起的回壓，低噪音型破碎機的功率可能略低於標準型破碎機。低噪音型破碎機的資料可向多家製造廠（包括本小冊子附錄A所列出者）查詢。

(b) 手提油壓破碎機

手提油壓破碎機不會產生排氣噪音，故與氣動破碎機的情況不同。因此，手提油壓破碎機噪音所造成的滋擾較為輕微，其噪音聲級一般較同様大小的氣動破碎機所發出的噪音低7分貝(A)。然而，大型油壓破碎機的情況不同，因其主要的噪音是從機身發出。
使用油壓系統或氣動系統所需的費用，兩者相差不遠。事實上，
採用油壓系統較採用氣動系統更合乎經濟效益，尤以長期性的操
作費用為然。有關手提油壓破碎機的資料可向多家製造商（包括
本小冊子附錄 B 所列出者）查詢。

(c) 裝在挖土機上的破碎機

裝在挖土機上的氣動或油壓碎石機，在一般建築機動設備中，屬
於噪音量最大的兩種，其噪音聲級相當於柴油錘打樁工程所產生
的噪音。圖 4 所見是一套市面上有售的隔音鋼錘托架，只適用於
一些類型的油壓破碎機。該托架以特別合金製造，內部裝上隔音
材料。如鋼錘裝上全套托架，便可將噪音減低 10 分貝 (A)。油壓
破碎機安裝此種托架所需的費用端視該破碎機的大小及容量而
定，一般而言，約為鋼錘本身價值的百分之十至二十之間。

圖 4 隔音鋼錘托架
（蒙 Krupp Industrietechnik 特許轉載此圖）

1.3 其他破碎混凝土或石頭的技術

下文所介紹的，是一些可供採用的寧靜破碎混凝土或石頭的技術。此
等技術可取代傳統的撞擊式工具。有關製造商的詳情，請參閱本小冊子附
錄 C。
(a) 裝在挖土機的油壓夾混凝土機

油壓夾混凝土機，可將混凝土或其他堅硬材料屈折或折斷，故可避免產生兩物撞擊的噪音（見圖5）。此種夾混凝土機，亦適用於夾碎混凝土地基，溝槽路面、地板、混凝土柱塞及其他須予削切或露出混凝土鋼筋的結構物體。根據製造商提供的數據，該機夾鉗的夾力可達90公噸。夾碎混凝土時所產生的噪音十分輕微，其總噪音聲級，並不高於挖土機所發出的音量。此外，該機可毋須經過重大改裝便可以更換上挖斗，改作挖土之用。

(b) 氧氣切割槍 (Thermal lance)

使用氧氣切割槍 (Thermal lance)，用以鑽孔或削切物料，是一種寧靜的切割技術，並可與其他拆卸方法，一併使用。它能將混凝土或事造物體，削切為小塊，然後再用挖土機清除。氧氣切割槍 (Thermal lance) 是由一條塞滿多條鋼枝的鋼管，透過一條喉管及一個氧氣調節閥，連接氧氣槽而構成。燃點的氧氣切割槍，使鋼枝受熱，其產生的火焰，高達攝氏3,500度，溫度足以削切或燒穿混凝土（見圖6）。

(c) 非爆炸性的化學劑

此類化學劑可於市面購得。操作原理是將化學劑放進预先鑽於石頭或混凝土的孔洞裡，化學劑隨之硬化及膨脹，導致石頭或混凝土的裂口增大而破碎（見圖7）。鑽孔的深度、直徑及所在位置均經審慎設計，務使裂口盡量擴張。破裂的石頭或混凝土最後由挖土機清除。

(d) 小型夾混凝土機

此機內有一具低噪音型的電力壓縮器及一對油壓鉗，適當用以拆除混凝土牆。較大型的夾混凝土機是以鋼索代替人手控制夾混凝土機的位置（見圖8）。根據製造商所提供的數據，夾鉗的力度強達52公噸。使用此法以夾碎混凝土時所發出的噪音遠低於傳統上採用的氣動破碎機。此機於市面上有售，大小俱備。

(e) 混凝土槽壓碎機

此機已在市面上有售，特別用以壓碎混凝土槽而不致發出過量的噪音。該機主要由多個用油壓操作的活塞組成。該等活塞均具有尖銳的末端，依中心方向運作，並在向前混凝土槽時，對混凝土產生一股強大的壓縮力，將混凝土壓碎，而又不損鋼筋（見圖9）。
Cardox 系統 (炸藥代用品)

Cardox 系統以二氧化碳放出的高壓力，使堅硬的物料破裂，包括石頭、鋼筋混凝土或大塊混凝土。Cardox 系統主要是由一些充滿液態二氧化碳的高拉力鋼管組成，並將之放置在待擊碎的物料的鑽孔內。通電之後，二氧化碳隨即以高壓釋出。此種由氣體所產生的壓力足以將有關的物料破裂（見圖 10）。

(蒙 Allied Construction Equipment Ltd. 特許轉載此圖)

(蒙 Nippon Pneumatic Mfg. Co. Ltd. 特許轉載此圖)

圖 5 裝在挖土機的油壓夾混凝土機

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圖 6 氧氣切割槍 (Thermal lance) 的裝置及其操作
（蒙香港氧氣有限公司特許轉載此圖）

圖 7 不使用炸藥的拆除方法
（蒙 ONODA Corporation 特許轉載此圖）
圖 8 小型夾混凝土機
(蒙 Diaber 特許轉載此圖)
1.4 各種破碎混凝土或石頭的機動設備的噪音聲級

各種破碎混凝土或石頭的機動設備的噪音聲級見於表1。如有可能，應在工程的設計及施工階段考慮採用噪音較少的設備。至於量度某些特別類型的破碎混凝土或石頭的機動設備的噪音聲級，可向本小冊子「參考文獻」部分第一項及第二項參閱有關資料。
### 表 1 — 各種混凝土或石頭破碎機動設備的噪音聲級比較

<table>
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<th>接受測試設備的重量</th>
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<td>手提型氣動破碎機 (標準型)</td>
<td>[圖表]</td>
<td>36 千克</td>
</tr>
<tr>
<td>手提型氣動破碎機 (備有排氣減聲器)</td>
<td>[圖表]</td>
<td>36 千克</td>
</tr>
<tr>
<td>手提型氣動破碎機 (備有排氣隔音罩及機身的減聲器)</td>
<td>[圖表]</td>
<td>36 千克</td>
</tr>
<tr>
<td>手提油壓破碎機</td>
<td>[圖表]</td>
<td>30–32 千克</td>
</tr>
<tr>
<td>氧氣切割槍 (Thermal lance)</td>
<td>[圖表]</td>
<td>—</td>
</tr>
<tr>
<td>小型夾混凝土機</td>
<td>[圖表]</td>
<td>—</td>
</tr>
</tbody>
</table>

### 2. 各類機動設備的動力供應器

#### 2.1 噪音源及控制噪音的技術

大部分固定式的機動設備（例如壓縮機、發電機、混凝土泵及焊接設備）及推土設備（例如挖土機、推土機、裝載機及卸土車的動力）是由內燃機發動。茲將內燃機的主要噪音源列如下：

(a) 排氣噪音

排氣噪音產生的原因是排氣閥打開時突然將空氣排入排氣系統。噪音沿排氣管傳至其末端的排氣出口，然後向外散播。如排氣系統溢氣及排氣管安裝鬆脫，噪音便會大為增加。

設計適當、保養妥善的排氣減聲器可減輕排氣時所造成的噪音量。
(b) 冷卻系統噪音

冷卻系統噪音是由水泵、皮帶、滑輪及冷卻風扇所造成。冷卻風扇是冷卻系統中主要的噪音源。設計欠妥及損壞的風扇葉片均可能因空氣流動的改變而致噪音大增。如要減低冷卻系統發出的噪音，可以用合乎空氣流動模式的風扇取代，亦可裝置一個按風扇輪廓設計，減少與風扇尖端間隙的覆蓋或通風裝（整流罩），移去入氣口一切的障礙物，例如鐵枝及管，或採用恆溫器控制風扇開關。

(c) 引擎噪音

引擎發出的噪音是與燃燒過程及各種組件（例如齒輪、軸承及活塞）而發出的機械噪音有關。

![圖11 內燃機及附件的主要噪音來源](image)

一般而言，要減低引擎噪音，只需將原有的組件加以改裝便可。然而，亦可為會發出噪音的個別組件設置一部特別設計的局部或全部隔音罩，及在電動機組加裝阻尼減震物料，將主機個別組件的震動隔離，便能減低噪音（見圖12）。局部或全部隔音罩可將噪音聲級分別減低10及25分貝(A)（見圖13）。 (參考文獻第6項)。
2.2 低噪音型機動設備

使用內燃機動力供應器的機動設備所發出的噪音量各不相同，視乎那一家製造商而定。低噪音型的柴油或汽油發電機，隨時可在市面上購置。此類設備是根據上文第2.1節所描述的減音原理製造。其噪音量與價值亦視乎那一家製造商製造而定。標準型與低噪音型發電機的售價或租值相差約百分之十至十六。有關低噪音型柴油或汽油發電機及動力供應器的資料可向多家製造商（包括本小冊子附錄D所列出者）查詢。
切勿為通風原因而打開機動隔音罩的嵌板或活板，因為此舉反而會導致機件過熱，並會大大增加發出的噪聲聲量。

3. 流動式空氣壓縮機

3.1 噪音源及控制噪音的技術

空氣壓縮機的噪音主要是由柴油引擎、引擎排放廢氣、冷卻風扇、放氣活門及空氣的進出口所造成。此類噪音，可以根據上文第2.1節所描述的方法予以減低。現時廣泛用於建築業的壓縮機有不對稱螺旋式及轉轉式，其優點有：結構堅實、操作效率高、保養容易及所發出的噪音聲級低於往復式的壓縮機。如有電源供應，則最好使用電動空氣壓縮機，因此種壓縮機操作較為寧靜。如需要進一步隔音，則電動壓縮機比柴油引擎壓縮機更容易改裝。

3.2 低噪音型機動設備

低噪音型的機動設備可以隨時在市面上購得。一般而言，要減低其噪音，可在罩蓋內加上吸音棉墊，亦可使用隔音器隔音以及利用避震器將引擎及壓縮機與底座盤分隔。而超低噪音型壓縮機亦在市面上有售。大部分低噪音型壓縮機均符合歐洲共同體的製造法規或美國環境保護局所訂的噪音排放標準。有關低噪音型流動式空氣壓縮機的資料可向多家製造商（包括本小冊子附錄E所列出者）查詢。

切勿為着通風原因而打開機械隔音罩的嵌板或活板，因為此舉反而會導致機件過熱，並會大大增加發出噪聲的聲量。

表2 所載乃標準型壓縮機與低噪音型壓縮機兩者之間的費用差距。

### 表2——標準型壓縮機與低噪音型壓縮機兩者之間的費用比較

<table>
<thead>
<tr>
<th></th>
<th>距離壓縮機7米處的最高噪音聲級(分貝(A))</th>
<th>費用的平均差距</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>費用的平均差距</td>
</tr>
<tr>
<td></td>
<td></td>
<td>租用</td>
</tr>
<tr>
<td>標準型</td>
<td>77–85</td>
<td>一</td>
</tr>
<tr>
<td>低噪音型</td>
<td>75</td>
<td>20%</td>
</tr>
<tr>
<td>超低噪音型</td>
<td>70</td>
<td>40%</td>
</tr>
</tbody>
</table>
4. 控制工地噪音办法

4.1 選擇寧靜的機動設備

為盡量減低建築工程所帶來的噪音滋擾（此舉可同時減輕工人過度暴露於噪音環境下工作）須使用低噪音的設備。在可能範圍內，應選用最寧靜的設備。舉例而言，柴油機動設備應以電動設備取代，而氣動破碎機則以手提油壓機取代。不應使用動力過大或過小的設備。

4.2 選擇機動設備的擺放位置

噪音量大的設備的所在位置應盡可能遠離「噪音感應強的地方」，例如住宅樓宇、學校或醫院等。如附近有任何可作隔音的建築物，例如地盤臨時辦事處、冷卻水箱，均可利用之作為遮隔噪音的屏障用。

4.3 編定施工作程

為盡量減輕噪音滋擾，可審慎地安排施工時間及程序，避免在噪音敏感時間內（例如學校上課時間，特別是考試時間）進行產生噪音量大的工程。此外，噪音量大的機動設備不應開動過久，如非使用時，應予以關掉。

在可能範圍內，清除泥土堆或地形隔音屏障的工作應由距離「噪音感應強的地方」較遠的一邊泥土堆或地形隔音屏障開始（見圖14），使泥土本身亦可發揮隔音屏障作用，藉以減低噪音聲級及使「噪音感應強的地方」遭受噪音滋擾的時間減至最少。挖土時亦可採用類似辦法進行。

4.4 使用隔音屏障

減輕噪音的其中一件有效方法，便是將發出噪音的機動設備放在隔音屏障之後。該等隔音屏障可利用現成的建築材料，在地盤實地裝造，亦可
利用市面上售的，覈有吸音材料的嵌板建造，務求獲取最佳的隔音效果。要達至最佳效果，隔音屏障的位置應盡可能接近噪音源或受噪音影響的地方，同時，儘可能避免屏障的接合處留有空隙或缺口。作屏障用的材料平面質量，要超過每平方米 7 千克為合，俾可收最佳的隔音效果。

屏障的長度，一般最少是其高度的五倍，而其高度最少則應該在受保護的「噪音感應強的地方」，不能看見噪音源的任何部分為準。此隔音辦法可輕易地將噪音減低 5 至 10 分貝 (A)。圖 15 便是其中一種吸音嵌板及一面裝妥，用以阻隔由卸土車造成的噪音的隔音屏障。

( 吸音嵌板 )
( 蒙 ASAHI Glass Co. Ltd. 特許轉載此圖 )

( 用以阻隔由卸土車造成的噪音的隔音屏障 )
圖 15 隔音屏障

4.5 使用機械隔音罩

固定的機動設備使用隔音罩可減低噪音高達 20 分貝 (A)。隔音罩應盡可能將機械完全遮蓋，罩內應覆上吸音材料，例如礦渣棉、鉻屑、專利吸
音瓦或玻璃纖維。此種隔音罩可用各類現成的建築材料造成。表3所載便是部分的建築材料的最高減音幅度。隔音罩如有任何缺口，均會減低隔音的效果，故應盡量減少。

機械的隔音罩如設安裝通風設備，則其進氣口及出氣口均應裝上設計妥善的減聲器，或將隔音罩作當善的設計及安裝，如圖16所示。

至於使用噪音量大，如手提氣動破碎機的機械以進行工程時，亦可利用類似的隔音原理，將會發出噪音的機械，作全部或局部圍封（見圖17）。

在挖掘隧道工程方面，廢土或掘出的物料應盡可能經全面圍封的輸送帶系統運離工地，避免使用噪音大的卸土車於夜間運載。而最佳的方法，莫如在夜晚，預先將掘出的泥土或雜物，送往經過隔音處理的場地（見圖18）然後在日間始行將之運離。

有關吸音材料及減聲器的資料可向多家製造商（包括本小冊子附錄F及G所列出者）查詢。

表3——製造機械隔音罩的材料

<table>
<thead>
<tr>
<th>材料</th>
<th>厚度（毫米）</th>
<th>平面質量（千克/平方米）</th>
<th>最高可減音（分貝(A)）</th>
</tr>
</thead>
<tbody>
<tr>
<td>磚牆</td>
<td>113</td>
<td>220</td>
<td>35-40</td>
</tr>
<tr>
<td>馬糞紙</td>
<td>50</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>硬紙板</td>
<td>18</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>塑膠板</td>
<td>13</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>纖維板</td>
<td>12</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>夹板</td>
<td>6</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>

4.6  保養機動設備

多種機動設備應由曾受訓練的人員定期妥善保養，此舉可延長其使用壽命及減低噪音量。噪音的增加，往往顯示有關機械即將出現故障。所有各部件均需定期檢查，運轉的零件應以潤滑油保持潤滑。鬆脫的零件應予收緊，如有磨損，則應予以更換。隔音設備亦需定期檢查。
4.7 監管及聲工程

噪音所造成的滋擾，例如呼叫、材料的碰撞，或敲擊鋼條等，均可透過嚴密監管及施工予以避免。地盤監督應採取適當的預防措施，確保一切機動設備的操作及施工，均不致擾及附近的「噪音敏感強的地方」。

圖16 機械隔音單示例

圖17 進行混凝土破碎工程時所採用的圍封物示例
圖18 存放掘出泥土的場地
第II部：打樁工程發出的噪音

5. 打樁噪音

5.1 撞擊式打樁法

傳統的撞擊式打樁方法，是利用衝擊的裝置，例如柴油錘、氣動錘、蒸汽錘或吊錘，將樁柱打入地下。此種方法，幾乎無法避免發出強而大的噪音，是故此類工程在多種噪音滋擾來源中，所佔的比重相當顯著。此種滋擾主要來自下述兩類噪音（見圖19）：

(a) 如錘鳴及撞擊的噪音

鋼錘重覆撞擊樁頭上的錘，導致撞擊物體與樁柱本身均產生震動，發出如錘鳴的噪音。噪音主要來自樁柱表面，其聲級的高低，則視乎樁柱本身所露出的表面面積而定。一般而言，露出的樁柱長度愈長，噪音聲級便愈高。

從發出的噪音方面而言，使用混凝土樁比較使用鋼樁為佳，此因混凝土本身，具有很高的防震特性，故發出的音調較為低啞，而滋擾程度亦顯然的為低。

(b) 排氣噪音

以氣動、柴油、蒸汽打樁錘而言，噪音主要是從排氣口放出壓縮氣體時所產生。排出的氣體的壓力一般仍是很高，故產生闌頻道的噪音。

下文第7節所描述的各種方法可用於控制噪音的來源或傳播。此外，又可採用第6.2至6.6節所載列的多種較為寧靜的專利打樁法。為減低打板鋼樁時發出的噪音，海外已發展到採用頂壓式打樁法，如第6.7節所介紹的Pilemaster打樁法，以取代撞擊式打樁法。頂壓式打樁法不會產生任何撞擊性的噪音。
5.2 非撞擊式打樁法

本港目前常用多種並不使用撞擊式打樁機的打樁法，例如利用震錘打鋼樁，利用旋轉式或螺旋式的鑽樁機，手挖沉箱法及在膠質黏土或灌注混凝土，以建築膜牆等。與撞擊式打樁法比較，此等方法不單產生較低的噪音聲級，且其滋擾程度亦較轻微，故在環境方面易為人所接受。

5.3 各種打樁法的噪音聲級

表4顯示，在距離15米處，使用所得的各種打樁方法所產生的等效連續聲級。在可能範圍下，應使用低噪音聲級的打樁方法進行打樁工程。
表 4——在距離 15 米處，量度各種打樁方法所得的等效連續聲級
（以分貝 (A) 表示）

<table>
<thead>
<tr>
<th>分貝 (A)</th>
<th>打樁方法</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>* 柴油錘打鋼樁</td>
</tr>
<tr>
<td>95</td>
<td>* 單動錘（氣動或蒸汽）打鋼樁</td>
</tr>
<tr>
<td></td>
<td>* 油壓錘打鋼樁</td>
</tr>
<tr>
<td>90</td>
<td>* 吊錘打鋼樁</td>
</tr>
<tr>
<td></td>
<td>* 油壓錘打混凝土樁</td>
</tr>
<tr>
<td></td>
<td>* BSP 撞擊打樁機</td>
</tr>
<tr>
<td>85</td>
<td>* 震動打樁機打鋼樁</td>
</tr>
<tr>
<td></td>
<td>* 吊錘打混凝土樁</td>
</tr>
<tr>
<td></td>
<td>* 大直徑的鑽樁（用抓斗 / 鏤 / 震動器）</td>
</tr>
<tr>
<td></td>
<td>* 螺旋鑽的鑽樁（備有標準型發電機 / 壓縮機）</td>
</tr>
<tr>
<td>80</td>
<td>* 內部吊錘（Frangi 機）</td>
</tr>
<tr>
<td></td>
<td>* 膜牆（備有標準起重機）</td>
</tr>
<tr>
<td>75</td>
<td>* 膜牆（備有低噪音型或電動起重機）</td>
</tr>
<tr>
<td></td>
<td>* 螺旋鑽的鑽樁（備有低噪音型的柴油 / 發電機 / 壓縮機）</td>
</tr>
<tr>
<td>70</td>
<td>* Hush 打樁系統</td>
</tr>
<tr>
<td></td>
<td>* 大直徑的鑽樁（反旋轉轉孔法）</td>
</tr>
<tr>
<td></td>
<td>* Pilemaster 打樁法</td>
</tr>
<tr>
<td>低於 65</td>
<td>* 手挖沉箱</td>
</tr>
</tbody>
</table>

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6. 較寧靜的專利打樁法

6.1 導言

下文各節所介紹的，是多種海外國家為減低打樁噪音而發展的較靜的專利打樁法。其中有多種目前已在香港使用，其餘的將來亦有可能為本港所採用。有關製造商的詳情見於本小冊子附錄 H。

6.2 內部吊錘

Franki 樁是本港最常使用的內部吊錘，其原理主要是利用內部吊錘的撞擊力，撞擊放置於鋼通底部的碎石，連同鋼通一併打入地下。其優點是在最初數錘以後，鋼通已經被打入地下，故進行撞擊時所發出的噪音來自鋼通的底部，其發出的噪音則被圓筒形的鋼通密封及因泥土具減震作用而減低。所以，此種方法所引起的噪音，主要是由打樁機本身的機器造成。

6.3 油壓錘

油壓錘的特色見於圖 20。

![圖 20 油壓錘式樣](蒙Uddcomb Sweden AB特許轉載此圖)
油壓錘的基本操作原理，是利用油壓缸經動力供應器產生的油壓動力，將衝頭提高至一個理想的撞擊高度，必要時油壓動力供應器可與錘架分開。此際，衝頭因重力作用而滑下，將強大的撞擊力打在樁柱上。衝頭的撞擊力，可以因應樁料的不同而調整。油壓錘打樁噪音的等效連續聲級一般視乎衝頭的落程及樁錘的撞擊率而定。

在土層較為鬆軟的土地上（標準貫穿試驗的N值少於10），使用油壓錘比裝柴油錘更為見效，因為後者沒有足夠的壓縮力以產生所要的爆炸。油壓錘其他的優點是不會發出任何排氣噪音，亦不會散發任何空氣污染物。

6.4 BSP 脈衝式打樁機

BSP 脈衝式打樁機是英國 BSP International Foundations 有限公司製造（見圖21）。

此種打樁機是種空氣推動的壓縮機，主要是利用衝頭與樁板之間的氣墊，以避免鋼與鋼互相撞擊時發出強大的噪音聲級。氣墊的作用，是減低最大的撞擊力，故有助於減輕樁柱的損壞。

氣墊不單可令該種打樁機的保養費用降低，同時，亦可將距離15米處的等效連續聲級減低至87-89分貝（A）。縱然，此種撞擊錘成本較為昂貴，但仍值得鼓勵使用。美中不足的是在地質堅硬的土層上操作，成效則未見愜意。雖然如此，事實上，此種撞擊錘已有見在本港使用。

![圖21 打板鋼塔的BSP ID17型脈衝式打樁機](蒙 BSP International Foundations Ltd. 特許轉載此圖)
6.5 Hush 打樁系統

Bachy (U.K.) 有限公司所採用的 'Hush' 打樁架，是利用完全密封式的減音原理。

密封的形式是以一個垂直的長方形箱子，將整具打樁設施及待打下的樁柱，單獨一條或成雙的套住。該箱子用作引導樁錘和樁柱，及在每次打樁前，均需確定樁柱筆直。箱邊設有一道用人力或油壓操作的門，俾放入樁柱。該箱由多節組合而成（每節均設門一扇），用以配合不同長度的樁柱。最低一節的門設有一觀察窗，以便操作人員能夠察看打樁的進度（見圖22）。為隔濾打樁錘的噪音，該箱的四週是由五層用鋼片附以富彈性的塑膠層組成，厚 16 毫米。在門隙一帶環以墊圈，如要高度隔音效果時，則須在箱底的四週，放置沙包。就以打垂直樁而言，據稱此種打樁機只需要樁柱後面與邊界牆或其他障礙物之間間 500 毫米，便可操作。

顧名思議，Hush 打樁機是以打工字樁時，特別寧靜而得名。此機亦適合用於混凝土樁及管形樁。Hush 打樁機可操作長達 24 米的樁柱，其體積及重量亦較其他打樁機為細及輕。

經過裝置固定打樁閥門後，Hush 打樁機的打樁速度可與傳統式打樁機相比。但以打板鋼樁而言，則板鋼樁的轉角及接合處，或許會出現多少困難。要解決此等問題，可在地盤實地製造特別的轉角樁及接合樁。

在距離 15 米處，量度 Hush 打樁機的等效連續聲級約為 70 分貝 (A)，因此，是屬於 '噪音量較低' 的打樁方法之一。
6.6 Delmag 減聲罩及JASPP型隔音蓋

柴油錘是噪音最強的其中一類撞擊式樁錘。為解決此問題，‘Delmag’製造了減聲罩 (Grunzweig + Hartmann Muffler)，而日本鋼管協會 (JASPP) 則製成 JASPP-NBK型和JASPP-NCK型的隔音蓋（見圖23）。

方法是用一個可一開為二的鋼蓋，開上吸聲材料，將樁柱及打樁設施，由頂到底完全遮蓋。在正常情況下，該遮蓋可將樁工程發出的噪音聲級減低20分貝(A)以上。又可減輕廢氣及油濺所造成的問題。此種打樁機設有強力的通風系統，供應清新的空氣給操作中的柴油錘。

由於遮蓋可開啟至180度，容易查看打樁時樁柱是否垂直，遮蓋的底部可上下來移動，方便在打樁機附近工作的人員及取得樁柱承受力的數據。

圖22 Hush吊錘打樁機
（蒙Bachy(U.K.)Ltd.特許轉載此圖）
然而，使用此種打樁機亦有其缺點，因安裝、調校及拆除遮蓋均需耗費時間及人力，此外，遇風速每秒超過10米時，打樁工程便必須停止，以策安全。

本港其中一項重大工程所採用的遮蓋，亦根據同樣原理而設計及安裝，結果將柴油錘打工字樁時所發出的噪音減低15分貝(A)。

6.7 SERF Pilemaster 打樁機

Pilemaster 打樁法是使用油壓機械將板鋼樁打入及拔出地層。操作時，只會引起很小的噪音及震動。Pilemaster 是由一個強力，附有鋼十字頭，內藏八個油壓錘配件組成（見圖24）。每個油壓錘壓着每件板鋼樁的頂部。操作時，由其中兩個油壓錘俯衝750毫米，從而將板鋼樁推入地底。此過程輪流在每對板鋼樁重覆進行，直至八件板鋼樁均插入750毫米為止。繼後，將油壓機降低，重覆前述的操作。

在黏聚力強達每平方米250 kN 的黏土、淤泥土壤，與及在標準貫穿試驗的 N 值少於15的幼砂層，操作 Pilemaster 機械時，其打樁的速率可與傳統式的打樁機相比，然而 Pilemaster 卻不能在石礫，或中等或粗砂土層運作。
在距離15米處量度，該打樁機械發出的等效連續聲級是介乎65至67分貝(A)，故Pilemaster打樁法是「噪音量較低」的打樁方法之一。

圖24 SERF Pilemaster油壓頂
（蒙SERF Ltd.特許轉載此圖）

7. 控制打樁噪音

7.1 採用較寧靜的打樁方法

在可行範圍內，應採用上文第5節所敘述的非撞擊式打樁方法打樁，例如螺旋式的鑽樁法。又或可用上文第6節所述的其他較寧靜的打樁法取代，以減輕打樁機發出的噪音。最重要的，還是要確保所有用於打樁工程的附屬設備（例如起重吊機、水泵、空氣壓縮機及柴油發電機）均屬低噪音型。

7.2 使用具有彈性的樁頭配件及墊盤

打樁工程如屬撞擊式，則應在保護樁頭的頭罩，裝上具有彈性的配件，放置在樁柱頂部，與及在樁錘撞擊的地方，加上一個墊盤（見圖25）。配件及墊盤應定期檢查和保養，保持良好的機械狀況。

7.3 使用隔音罩

如無法避免採用噪音量大的打樁法打樁，則應考慮以隔音罩圍封樁柱及打樁機。該套罩是用一個結實的框架，並裝上一層經過隔音設計的包層
（見圖26），或市面有售的現成隔音板。此外，亦可掛上一幅柔軟性厚身的乙烯基膠膜，將整條露出地面的樁柱及打樁機遮蓋（見圖27）。遮蓋可依照上文第6.5節及6.6節所述的原則設計及建造。有關隔音板及乙烯基膠膜的資料可向多家製造商（包括本小冊子附錄F所列出者）查詢。

7.4 減低鋼柱的震動

如要減輕如鐘鳴的噪音，可將鋼樁柱作減震化合物的處理，此種減震化合物可塗於或噴向樁柱的表面。有關此種減震材料的資料可向多家製造商（包括本小冊子附錄F所列出者）查詢。

7.5 編定施工作程序

為盡量減輕噪音滋擾，可透過小心安排的施工作程序，避免在噪音敏感時期內（例如學校上課時間，特別是考試期間）進行噪音量大的工程。此外，噪音量大的機動設備不應作不必要的開動，在毋須使用時，應立即予以關掉。

7.6 保養

打樁機動設備必須由受訓練的工作人員定期維修保養，因此舉有助於減輕機械引起的噪音及延長機械的使用壽命。

圖25 具有彈性的樁頭配件及墊盤
圖26 打樁用的隔音罩

圖27 打樁時所用的柔軟性乙烯基膠簿
（蒙 Peabody Noise Control 特許轉載此圖）
第III部：管制建築噪音的合約規格和條款

8. 概論

將管制噪音規格列入投標和合約規定內，有下列優點：

(a) 讓所有投標人士將管制噪音費用列入成本內；

(b) 尽量減少因提供消滅噪音措施的責任而引致的合約糾紛；

(c) 鼓勵有關人士以審慎及經濟效益角度，從事其工程的規劃工作，
    避免日後進行昂貴的機器改裝工作和延誤工程進度；

(d) 使公司形像更佳；及

(e) 承建商因採用較寧靜的方式作業，可使其獲簽發建築噪音許可證的機會提高。

有關規格大致分為下述類別（請參閱第9節表5一所列的樣本）：

(a) 使用裝設減聲器/寧靜的機器（見C1至C2）

(b) 採用其他寧靜的技術作業（見C3至C4）

(c) 裝設消減噪音的設備，例如減聲器、屏障或圍封物（見C5）

(d) 訂立工作時間限制噪音（見C6至C7）

(e) 維修機器（見C8）

(f) 規定噪音聲級限制（見C9至C10）

(g) 管制可避免的噪音（見C11）

(h) 遵守法例（見C12）；及

(i) 執行合約條款（見C13）

9. 投標和合約的規格

本節所列的規格樣本，旨在闡釋如何製訂管制噪音的規格。讀者可按
個別情況加以修訂引用。

為利便參閱起見，現將各規格及預期達到的目標，以圖表並排列出
（見表5）。
### 表5——規格樣本

<table>
<thead>
<tr>
<th>條款編號</th>
<th>目標</th>
<th>規格樣本</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>索取有關機器的資料</td>
<td>“投標者須根據投標文件的規定，提供資料，說明低嗓音型設備所屬的類別及型號及為非低噪音型設備的機器所採用的隔音辦法。不能提供上述資料者，可能導致取消其投標申請”</td>
</tr>
<tr>
<td>C2</td>
<td>使用裝置消減噪音設備的手提型破碎機 / 發電機 / 空氣壓縮機</td>
<td>“所有在地盤使用的手提型破碎機 * / 發電機 * / 流動型空氣壓縮機 * 必須是屬於附表一列的低噪音類型或獲（例如工程師）核准的同等類型。”（見下文附註） 附註：有關附表一的例子，請參閱本小冊子附錄 A、B、D、E 而自行製定。</td>
</tr>
<tr>
<td>C3</td>
<td>指定使用寧靜的破碎混凝土技術（特別是在噪音敏感的場所，毗鄰的地盤而言）</td>
<td>“地盤內不得使用任何石頭破碎機，只可採用附表二所列的破碎混凝土技術或獲（例如工程師）核准使用的同類技術。”（見下文附註） 附註：有關附表二內列出的其他破碎混凝土或石頭破碎技術的例子，請參閱本小冊子第 1.3 節，自行製定。</td>
</tr>
<tr>
<td>C4</td>
<td>採用寧靜打樁技術</td>
<td>“在地盤使用的所有打樁機器，必須屬於附表三內載的類型或獲（例如工程師）核准的同等類型。”（見下文附註） 附註：有關附表三的例子，請參閱本小冊子第4 自行製定。採用的打樁方法，應以在基準距離 15 米處，其噪音聲級為 90 分貝 (A) 或以下為合。</td>
</tr>
</tbody>
</table>

* 讀者可選用個別適合詞彙或將原文照錄
<table>
<thead>
<tr>
<th>條款編號</th>
<th>目標</th>
<th>規格樣本</th>
</tr>
</thead>
</table>
| C5 | 裝置消滅噪音設備 | “承建商得依循（例如工程師）的意見為有關機器裝設適合的減聲器、減音套、減音隔墊，隔音罩，或隔音屏障。”（見下文附註）
附註：有關屏障，圍封物等例子，請參閱本小冊第4節。 |
| C6 | 限定工作時間避免在晚間或學校考試期間進行噪音量大的作業工序 | “在_____至_____時間內不得在地盤進行破碎混凝土* /挖掘* /碎石* /打樁工作*。”（見下文附註）
附註：可根據鄰近任何「噪音敏感強的地方」，例如診所、教育院校（特別是考試期間）、法庭等作業時間，制訂工作時間限制。 |
| C7 | 限定打樁工程的最少工作時間 | “承建商須根據「管制撞擊式打樁工程噪音技術備忘錄」的規定，計算可准許進行撞擊式打樁工程作業的時間，確保地盤所採用的打樁設備的類別，每天可操作5*/12*小時。” |
| C8 | 避免因維修工作欠佳而造成噪音 | “承建商得採取（例如工程師）認為合理的預防措施，保持所有機器和減聲設備的性能良好，俾盡量減少在進行建築工程時所發出的噪音。而所有機器的維修費用得視為已包括在有關合約費用內。” |

* 讀者可選用個別適合詞彙或將原文照錄

95
<table>
<thead>
<tr>
<th>條款編號</th>
<th>目標</th>
<th>規格樣本</th>
</tr>
</thead>
<tbody>
<tr>
<td>C9</td>
<td>限制噪聲級以保障指定「噪聲敏感區」的地方</td>
<td>“承建商同意在建築工程中使用機器所發出的噪聲應級之設計，由（例如某醫院、學校）的最近外牆對開1米處量度，在任何5分鐘內，都不會超過等效連續噪聲級（Leq） 分貝（A）。違反此條款者，必須停止有關工程，直至獲（例如工程師）同意，才可復工。”（見下文附註）</td>
</tr>
<tr>
<td>C10</td>
<td>提供聲級計</td>
<td>“承建商在合約期間得隨時提供一部符合IEC標準651:1979（第一級）或804:1985（第一級）內載規格的聲級計，和一部聲音校正器（例如工程師）專用。承建商得按需要保養、修護及更換聲級計。聲級計會於合約期滿後歸還承建商。”（見下文附註）</td>
</tr>
<tr>
<td>C11</td>
<td>管制嘈吵建築工程</td>
<td>“承建商得採取所有由（例如工程師）制定的並以符合其所定規格為準的措施，確保地盤內使用的機器及進行的建築工程，不會產生必要及過量的噪聲，從而滋擾或煩擾鄰近的「噪聲敏感區」地方。”</td>
</tr>
</tbody>
</table>

附註：須根據「管制建築工程噪聲（運輸打枱除外）技術標準」，內載的「可接受的噪聲級」，嚴格一項噪聲級的極限，並須顧及地方性的噪聲環境及「噪聲敏感區」地方的特別情況。

附註：有關一般聲級計的校正程序，可參閱參考文獻4或5。
<table>
<thead>
<tr>
<th>條款編號</th>
<th>目標</th>
<th>規格樣本</th>
</tr>
</thead>
<tbody>
<tr>
<td>C12</td>
<td>遵守環境保護法例</td>
<td>“承建商得履行和遵照香港就管轄任何類別的污染（包括空氣及其他）及保護環境的現行條例，附例，規例和規則。”</td>
</tr>
<tr>
<td>C13</td>
<td>執行管制噪音的合約條款</td>
<td>“違反本合約____條款時，承建商得停止一切建築的工作或機器的操作。承建商不守條款規定而被（例如工程師）指令停工者，均不會因而獲准將完工日期延遲或獲得任何賠償。”</td>
</tr>
</tbody>
</table>
聲學詞彙

噪音 —— 噪音是任何一種聲音，這種聲音被人認為是不需要或令人煩擾的。

分貝 —— 是一個沒有確定度量的單位，它主要是聲功率或聲壓與一參考數值的比率，用對數表示。

聲功率級 —— 量度某一聲源所發出的總聲功率的計算單位，以分貝表示。它與參考距離或其他外來因素無關（以光源為例，它相當於一燈泡的功率，用瓦特表示）。

聲壓級 —— 量度某一點聲源的聲音壓力，以分貝表示。它與聲源的距離及其它外來因素有關（以光源為例，它相當於某一點光源的光度或強度）。

A加權分貝（即分貝） —— A加權分貝是量度環境噪音的常用單位，相當於人類耳朵對噪音的反應。

等效連續聲級 —— 在某段時間內的不同聲級的聲音能量總和，以一定聲音能量的聲級代替。

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。它可影響我們對聲音高低程度的感覺。
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3. CAGI-PNEUROP Test Code for the measurement of sound from pneumatic equipment.  
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附錄

在市面上售的寧靜建築機動設備、控制噪音的產品及
寧靜的混凝土破碎技術資料

有些商業機構，專為建築工業，訂購製造／供應／提供寧靜建築機動
設備、控制噪音材料及寧靜的混凝土破碎技術。下列的資料可以從這些製
造商或代理商查詢：

(a) 產品資料

(b) 試驗的數據

(c) 提議採用的產品

(d) 過往應用的事例

(e) 一般技術資料

(f) 成本資料
附錄 A
低噪音型手提氣動破碎機

<table>
<thead>
<tr>
<th>製造商</th>
<th>型號及型號</th>
<th>設備大小（千克）</th>
<th>空氣消耗率（立方米/分鐘）</th>
<th>本港潤滑代理商地址</th>
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<tr>
<td>Atlas Copco MCT AB</td>
<td>Atlas Copco TEX 11DCS TEX 22S TEX 32S TEX 42S</td>
<td>25–43</td>
<td>1.5–2.0</td>
<td>阿特拉斯（香港）有限公司 九龍觀塘偉業街 227–229 號二樓 電話：3-413213</td>
</tr>
<tr>
<td>CompAir Holman Ltd.</td>
<td>CompAir Zitec 14 Zitec 20 Zitec 27</td>
<td>14–38.7</td>
<td>1.2–2.0</td>
<td>高仕洋行有限公司 九龍彌敦道 610 號 荷李活商業中心 1303–1306 室 電話：3-851031</td>
</tr>
<tr>
<td>Ingersoll Rand Co.</td>
<td>Ingersoll-Rand BR 20S BR 30S BR 40S</td>
<td>23–37</td>
<td>1.7–2.0</td>
<td>森那美香港有限公司 信昌機器工程有限公司 芝灣青龍頭龍騰路 2–12 號 電話：0-4910621</td>
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</table>
# 附錄 B
手提油壓破碎機

<table>
<thead>
<tr>
<th>製造商</th>
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<th>設備大小 (千克)</th>
<th>油流量 (升/分鐘)</th>
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<td>JCB</td>
<td>25</td>
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<td>國際重機有限公司&lt;br&gt;香港鯉魚涌鴻福街&lt;br&gt;28號新業大廈12樓&lt;br&gt;電話：5-8118398</td>
</tr>
<tr>
<td>Maruzen Rogyo Co. Ltd.</td>
<td>Maruzen MHB 16 MHB 25 MHB 32</td>
<td>16-32</td>
<td>20-25</td>
<td>力高機械公司&lt;br&gt;九龍旺角登打士街2A地下&lt;br&gt;電話：3-320733</td>
</tr>
<tr>
<td>Stanley Hydraulic Tools</td>
<td>Stanley BR 37 BR 45 BR 67 BR 87</td>
<td>17-36</td>
<td>26-34</td>
<td>史丹利製造廠(香港)有限公司&lt;br&gt;香港單打街中建大廈1433室&lt;br&gt;電話：5-262983</td>
</tr>
</tbody>
</table>
附錄 C

較寧靜的混凝土破碎設備及技術

隔聲鋼錨托架

1. Krupp Industrietechnik GmbH
   Postfach 102144, Helenestraße 149, D-4300 Essen 1,
   Federal Republic of Germany.
   Faxline: 0201-3140501
   香港代理: Rokhammers
   九龍尖沙咀梳士巴利道三號星光行 1233 室
   電話: 3-7301001

裝在挖土機的夾混凝士機

2. Allied Construction Equipment Ltd.
   Dowsetts Lane, Ramsden Heath, Billericay, Essex, CM11 1JQ,
   England, U.K.
   Faxline: 0268-71091
   香港代理: 現時未有

3. Holemasters Concrete Cutting & Drilling Service
   Unit G3, Europa Trading Estate, Stoneclough Road, Radcliffe,
   Manchester, M26 9EH, U.K.
   Faxline: 0204-861226
   香港代理: 現時未有

   No. 11-5, 4-chome, Kamiji, Higashinari-Ku, Osaka, Japan.
   Telex: 529-6566
   香港代理: 聯業工程有限公司
   沙田大圍成運道 25-27 號成全工業大廈 1005 室
   電話: 0-6977223

5. Okada Aiyon Corp.
   4-1-18, Kaigan-dori, Minato-ku, Osaka 552, Japan.
   Faxline: 06-576-1260
   香港代理: 力高機械公司
   九龍旺角登打士街 2A 地下
   電話: 3-320735
6. 香港氧氣有限公司
九龍清水灣道坑口 317 地段 DD234
電話：3-7197100

非爆炸性的化學劑

7. Onoda Corporation
7th Floor, Okachimachi CY Building, No. 15-14, 5-chome, Ueno,
Taito-ku, Tokyo, Japan, 110.
Faxline: 03837-0726
香港代理：三井物産（香港）有限公司
香港夏愷道 16 號遠東金融中心 25-26 樓
電話：5-8238777

小型夾混凝土機

8. Holcemasters Concrete Cutting & Drilling Service
Unit G3, Europa Trading Estate, Stoneclough Road, Radcliffe,
Manchester, M26 9EH, U.K.
Faxline: 0204-861226
香港代理：現時未有

Victoria Way Burgess Hill, West Sussex, England, RH15 9NF, U.K.
Faxline: 0444-870297
香港代理：偉高模板工作台系統有限公司
新界大埔廣福道 152-172 號大埔商業中心 12/F
電話：0-6539328

10. Specialist Services (Cutting and Drilling) Ltd.
Specialist House, 52-54 Northern Road, Cosham, Portsmouth,
England, PO6 3DP, U.K.
Faxline: 0705-379682
香港代理：現時未有

11. Diaber Ag.
Diamantwerkzeugfabrik Ch-8700 Kusnacht-Zurich,
Telex: 825780 DIAB CH
香港代理：現時未有
12. Diaber Ag.
   Diamantwerkzeugfabrik Ch-8700 Kusnacht-Zurich,
   Telex: 825780 DIAB CH
   香港代理：現時未有

13. Pikrose and Company Ltd.
    Delta Works, Delta Road, Audenshaw, Manchester, M34 5HS.
    Telex: 0204-667488
    香港代理：禮頓建築（亞洲）有限公司
    香港皇后大道東183號合和中心49樓
    電話：5-8231111

105
低噪音型的柴油/汽油發電機及動力供應器

<table>
<thead>
<tr>
<th>製造商</th>
<th>牌子名稱及型號</th>
<th>在频率50「赫」負荷的輸出功率以千瓦表示</th>
<th>本港認可代理商地址</th>
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</table>
| Denyo Co. Ltd.    | Denyo DCA type:—
15SS-N, 90SPH
22SPN, 125SPK
25SPM, 220SSA-K
45SPH, 250SSA-C
45SPH, 380SSA-M
60SPI, 380SSA-K
60SPH, 600SSA-K
75SPH, 750SSA-M  | 12.5-650（柴油發電機） | 合碟汽車有限公司
九龍太子道西154-158號三字樓
電話：3-975111 |
| Honda Motor Co. Ltd. | Honda EX 650
EX 2200
EX 3000
EX 3000S
EX 3300S
EX 4000S
EX 4500S
EM 650 | 0.45-5.0（汽油發電機） | 合碟汽車有限公司
九龍太子道西154-158號三字樓
電話：3-975111 |

<table>
<thead>
<tr>
<th>製造商</th>
<th>牌子名稱及型號</th>
<th>輸出功率以千瓦表示</th>
<th>本港認可代理商地址</th>
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| Hatz Motorenfabrik Gm bH | Hatz L31C
L40C | 9.5-51（柴油動力供應器） | 潇機工程有限公司
九龍尖沙咀龍利士巴利道三號
星光行1233室
電話：3-7301001 |
## 附錄 E
### 低噪音型的流動空氣壓縮機

<table>
<thead>
<tr>
<th>製造商</th>
<th>品名及型號</th>
<th>在7千克/立方釐米（100磅/平方呎）的壓力下空氣輸出率（立方米/分鐘）</th>
<th>本澳認可代理販售地址</th>
</tr>
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<tbody>
<tr>
<td>Atlas Copco</td>
<td>Atlas Copco</td>
<td>1.8–25.5</td>
<td>阿特拉斯(香港)有限公司 九龍觀塘協和街 227–229 號二樓 電話：3–413213</td>
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<td>MCT AB</td>
<td>XAS 60Dd</td>
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<td>XAS 85Dd</td>
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<td>XAS 125Dd</td>
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<td>XAS 175Dd</td>
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<td>XAS 350Dd</td>
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<td>CompAir Holman Ltd.</td>
<td>CompAir Zitair 70–9</td>
<td>2.0–34.0</td>
<td>高仕祥行有限公司 九龍彌敦道 610 號 荷李活商業中心 1303–1306 室 電話：3–851031</td>
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<td>Zitair 85, 600–1000S</td>
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<td>Zitair 250</td>
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<td>Zitair 400–125</td>
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<td>Denyo Co. Ltd.</td>
<td>Denyo DPS-90SS</td>
<td>2.5–17.0</td>
<td>合群汽車有限公司 九龍太子道西 154–158 號三字樓 電話：3–975111</td>
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<td>DPS-130SS</td>
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<td>DPS-175SS</td>
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<td>DPS-250SS</td>
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<td>DPS-370SS</td>
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<td>DPS-600SS</td>
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<td>Ingersoll-Rand Co.</td>
<td>Ingersoll-Rand Whisperized types—</td>
<td>2.4–45.3</td>
<td>森那美香港有限公司 信昌機器工程有限公司 花園青龍頭龍騰路 2–12 號 電話：0–4910621</td>
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### 附錄F
防聲及隔聲材料

<table>
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<tr>
<th>製造商</th>
<th>塑子名稱及產品</th>
<th>本港認可代理商地址</th>
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</table>
| ASAHI Glass Co., Ltd.| **Glasron** 防聲板           | 鑫輝有限公司  
香港鴻福道348-350號恒發商業大廈二樓  
電話：5-8910848                                           |
| Industrial Acoustics Co.  
Hong Kong Ltd.  | **IAC** 隔音板、隔音屏障、隔音罩 | 雅士消聲器材(香港)有限公司  
香港皇后大道東183號合和中心2410室  
電話：5-8611891                                             |
| Industrial Noise Control | **Decibe** 隔音的特製海綿、隔音保護面、  
具吸音及阻尼減震材料的合成隔音屏障                   | 仙聲(香港)有限公司  
香港銅鑼灣怡和街48號帝富大廈三樓  
電話：5-770636                                             |
| Peabody Noise Control | **Kinetics** 隔音的特製海綿、具吸音的乙烯基、  
隔音屏障、具阻尼減震的複合隔音板障，隔音合成物、避震器、隔音罩 | 美國聯和(香港)有限公司  
香港中環都爹利街6號印刷行六樓  
電話：5-251169                                             |
### 附錄 G

#### 減聲器

<table>
<thead>
<tr>
<th>製造商</th>
<th>牌子名稱及產品</th>
<th>本港認可代理商地址</th>
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<td>A Boët</td>
<td>A Boët</td>
<td>Federation of French Mechanical Industries</td>
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<tr>
<td></td>
<td></td>
<td>香港中環德忌立街 38-40 號好利商業大廈十八樓 E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>電話：5-257570</td>
</tr>
<tr>
<td>Industrial Acoustics Co.</td>
<td>IAC</td>
<td>推士消聲器材 (香港)有限公司</td>
</tr>
<tr>
<td></td>
<td></td>
<td>香港皇后大道東 183 號合和中心 2410 室</td>
</tr>
<tr>
<td></td>
<td></td>
<td>電話：5-8611891</td>
</tr>
<tr>
<td>NAP (Aust) Pty. Ltd.</td>
<td>NAP Silentflo</td>
<td>仙壁 (香港) 有限公司</td>
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<tr>
<td></td>
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<td>香港銅鑼灣怡和街 48 號麥當奴大廈三樓</td>
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<tr>
<td></td>
<td></td>
<td>電話：5-770636</td>
</tr>
<tr>
<td>Sound Attenuators Ltd.</td>
<td>SAL</td>
<td>美國聯和 (香港) 有限公司</td>
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<td>香港中環都爹利街 6 號印刷行六樓</td>
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<tr>
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<td>電話：5-251169</td>
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</tbody>
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附錄 H

較寧靜的專利打樁法

內部吊錘

1. 香港代理：建新建築有限公司
    九龍九龍塘聯合道320號建新中心2-3樓
    電話：3-398222

油壓錘

2. BSP International Foundations Ltd.
    Claydon Industrial Park, Gipping Road, Gt. Blakenham, Ipswich, Suffolk, IP6 0JD, England, U.K.
    Faxline: 0473-832019
    香港代理：維昌洋行有限公司
    香港仔黃竹坑道53號英基工業中心二十六樓
    電話：5-555555

3. DELMAG-Maschinenfabrik, Reinhold Dornfeld GmbH & Co.
    D-7300 Esslingen (West-German), Max-Planck. Straße. Postfach 190.
    Faxline: 0711-3950111
    香港代理：菲高工程有限公司
    九龍尖沙咀梳士巴利道三號星光行1233室
    電話：3-7301001

4. Nippon Sharyo Ltd.
    Kaisei Bldg. 13-2, Nihonbashi Kabuto-cho, Chuo-ku, Tokyo 103, Japan.
    Faxline: 03-669-0238
    香港代理：現時未有

5. Uddcomb Sweden AB
    Box 523, S-371 23 Karlskrona, Sweden.
    Faxline No: 0455-262-46
    香港代理：裕基工程建設有限公司
    九龍長沙灣郵局郵政信箱80396號
    電話：3-935733
脈衝式打樁機

6. BSP International Foundations Ltd.
   Claydon Industrial Park, Gipping Road, Gt. Blakenham, Ipswich, Suffolk,
   IP6 0JD, England, U.K.
   Faxline: 0473-832019
   香港代理：維昌洋行有限公司
   香港仔黃竹坑道 53 號英基工業中心二十六樓
   電話：5-555555

密封打樁設施

7. Bachy (UK) Ltd.
   Foundation Court, Godalming Business Centre, Catteshall Lane,
   Godalming, Surrey, GU7 1XW, U.K.
   Faxline: 04868-7021
   香港代理：現時未有

8. DELMAG-Maschinenfabrik, Reinhold Dornfeld GmbH + Co.
   D-7300 Esslingen (West-Germany), Max-Planck. Straße. Postfach 190.
   Faxline: 0711-3950111
   香港代理：菲高工程有限公司
   九龍尖沙咀梳士巴利道三號星光行 1233 室
   電話：3-7301001

   3-2-10, Nihonbashi-Kayaba-cho, Chuou-ku, Tokyo 103, Japan.
   Faxline: Tokyo 669-1685
   香港代理：現時未有

Pilemaster 打樁機

10. Serf Ltd.
    P.O. Box 35, Oldham, Lancs, England, U.K.
    Faxline: 667473
    香港代理：現時未有
This book is due for return or renewal on the date shown unless previously recalled. Fines may be incurred for late return.

DATE DUE

36 JUN 2003

17 JUN 2004
A Practical guide for the reduction of noise 1989.