ENVIRONMENTAL NOISE GUIDELINES FOR INSTALLATION OF RESIDENTIAL AIR CONDITIONING DEVICES

SEPTEMBER 1994

Ontario

Ministry of
Environment
and Energy

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- Air-Conditioning and Refrigeration Institute; Arlington, Virginia
- Carrier Corporation, New York

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1. INTRODUCTION

Noise generated by the outdoor section of AC & HP (air conditioner and heat pump) units is becoming a major concern in most communities as evidenced by the increasing number of complaints lodged by Ontario residents. As available land for the development of new housing in urban areas is in rapid decline, there is an increased trend toward high density housing projects. The close proximity of residential lots, typical for new housing developments, often results in a situation where an AC or HP unit is installed on the lot line or right under the neighbour's open window, generating excessive noise and causing serious annoyance.

According to noise complaint statistics assembled by the City of Toronto Noise Group, HVAC (heating, ventilating and air conditioning) units account for 15% of all noise complaints (an annual average for years 1977 to 1985). Earlier complaint statistics prepared by the Ministry of the Environment indicate that 25% to 27% of all noise complaints lodged by Ontario residents resulted from the operation of AC & HP units.

It became apparent that little information is available about effective noise abatement measures applicable to this type of equipment and the associated cost. The recommended practices for the installation and placement of units in such a way that the resultant noise impact is eliminated, or at least minimized, are often not followed.

Although standards for AC sound rating, noise impact evaluation procedure and recommended installation practices, developed by the Air Conditioning & Refrigeration Institute (ARI) in the U.S., have been available since 1967, only a few installers are familiar with the standard document. The buyers and users of AC & HP units are generally not informed about the potential for noise impact, and the possibility of or method for predicting the noise levels of their purchased installations. Consumers know even less about ways to avoid problems or retrofit their unit for noise control.

2. OBJECTIVE AND SCOPE

2.1. Objective

It is the objective of this publication to provide uniform guidelines for the installation of residential air conditioning systems with regard to environmental noise potential. This publication is also intended to serve as a reference for provincial guidelines, criteria, municipal by-laws, Building Code regulations, consultants, manufacturers, installers, and the public at large.

2.2. Scope

This publication provides information on criteria for acceptable sound level limits due to operation of residential air conditioning systems, environmental noise impact evaluation procedures, and installation guidelines.

References related to legislation, equipment and testing procedures, and other publications provided by the air conditioning industry and regulatory agencies are also included.

3. IDENTIFICATION OF NOISE SOURCES

The major component of environmental noise from the air conditioning system is the condensing equipment. In the case of the central air conditioning "split system", only the outdoor unit is the noise source. The condensing package is also responsible for the noise in window units and through-the-wall incremental units.

A small number of complaints dealing with excessive noise from outdoor units can be attributed to poor workmanship during assembly. Loose or faulty bearings, improperly installed or out of balance compressors, fan wheels or cages, damaged wheels or bent blades may be sources of excessive noise. Generally, the high sound levels are associated with the following equipment:

(i) Fans

Noise from the fan is generated by the fan blades passing through the air. The level of sound generated by the fan operation vary depending on the number of fan blades, fan speed (RPM), wheel diameter, clearance between the fan blade and fan housing, and the rate at which air is being discharged. Higher than normal sound from the fan may also be due to improper balancing of the fan, loss of a bearing, damaged fan blades and from rattling of fan components.

(ii) Compressor

Compressor noise originates from inside the sealed self-contained housing which contains both the electrical motor and the actual refrigerant pump. The noise comes from valves and rubbing surfaces, and from the response of other components to generated sound.

(iii) Turbulence

Part of the sound emitted from a condensing unit is of aerodynamic origin, as the fan discharges air through the cooling fins surrounding the condenser coils. Another sound source that is also associated with air flow is air deflection. The air discharged by the condensing unit may be channelled through duct work and deflectors which could also generate noise.

(iv) Equipment Casing

Although not a source itself, the unit's panelling is often set into sympathetic vibration because of the vibration of the motor, compressor and the fan. The extent of the panel vibration is dependent on the panel stiffness and the degree of vibration isolation attributed to the components.

In the great majority of cases, however, the noise problems could be attributed to the poor choice of location for the outdoor unit and the fact that little, if any, consideration is being given by the installers

to the noise potential of this unit. The recommendations for locating the outdoor unit and details of conventional abatement techniques are discussed in Sections 7 and 8.

4. SOUND TEST REQUIREMENTS

Sound testing of unitary air conditioners and heat pumps must be conducted in accordance with " Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms, Precision Methods for the Determination of Sound Power Levels" (American National Standards Institute, Standard S12.32-1990). The test requirements include both the actual sound level measurement procedure and the specific unit conditions under which the tests must be carried out. This testing is normally done by the manufacturer.

The Air-Conditioning and Refrigeration Institute (ARI) has established a method of sound rating outdoor unitary equipment. Material related to this section can be found in ARI Standard 270-84, "Standard for Sound Rating of Outdoor Unitary Equipment".

5. SOUND RATING PROCEDURE

The Air-Conditioning and Refrigeration Institute developed a Sound Certification Program to rate the noise of air conditioners and heat pumps in terms of tone corrected A-weighted sound power level. In 1967, ARI introduced a Sound Rating Number, which combined a frequency weighting factor for loudness and a pure tone correction for annoyance. In the 1982 version of ARI Standard 270 the pure tone penalty is applied to 1/3 octave band sound power levels of the unit. These sound power levels are then A-weighted and the 1/3 octave levels are then summed into the tone corrected A-weighted single number ARI Sound Rating. The complete rating procedure can be found in ARI Standard 270-84, "Standard for Sound Rating of Outdoor Unitary Equipment" (see reference 21).

6. EVALUATION OF SOUND LEVELS DUE TO AIR CONDITIONER/HEAT PUMP OPERATION FOR A GIVEN INSTALLATION

6.1 Areas of Concern

Sound pressure level estimations should be made for each area of concern to evaluate the equipment installation from an acoustic standpoint. These areas of concern include any point on the premises where sound or vibration originating from other than those premises is received.

Examples of areas of concern include patios, outdoor living areas, balconies, recreational facilities, communal lounges and other developed areas within a site which are judged to be specifically designed to serve as useful areas for active or passive recreation of the residents. Also included in the areas of concern would be all rooms within the residence itself.

6.2 Sound Level Calculation Procedure

The basic procedure for estimating the dBA sound pressure level at a given point of evaluation is described in ARI Standard 275-84 "Standard for Application of Sound Rated Outdoor Unitary Equipment". The sound level of outdoor unitary equipment in various applications is dependent not only upon the ARI Sound Rating but also upon several significant factors related to the application of the equipment. Quantitative values for each of these factors are established to adjust the sound rating as shown in the following summary:

Sound Rating x 10	_____
+ Equipment Location Factor	_____
- Barrier Shielding Factor	_____
- Sound Path Factor	_____
- Distance Factor	_____
Estimated A-Weighted Sound Pressure Level (±5 dB)	_____ dBA

The definition of the application factors and details of the Calculation Procedure are given in the following section.

6.3 Application Factors for Estimating A-Weighted Sound Pressure Level

(i) Equipment Location Factor

This factor takes into consideration the effect of walls and other reflecting surfaces adjacent to the equipment. Factors for typical equipment locations are given in Table 1.

(ii) Barrier Shielding Factor

This factor accounts for the sound reduction benefit of any solid structure that obstructs the line of sight (or sound) from the equipment location to the point of evaluation. Such a barrier may be the corner of a building, the edge of a roof, or a heavy wall of masonry, etc., built for the specific purpose of shielding an area of concern from the unit generated noise. See Table 2 for sketches and the values of barrier factor.

(iii) Sound Path Factor

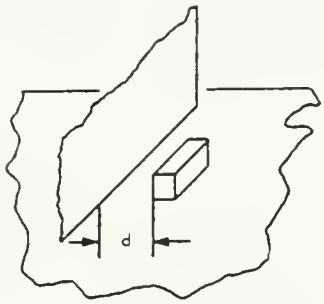
This factor adjusts for the path of sound from the unit to the point of evaluation. This path may lead to the outdoors only, to a room through open windows, to a room through closed windows, or through a wall. See Table 3 and the sketches included.

(iv) Distance Factor

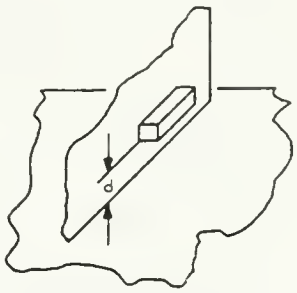
The direct distance, D, from the equipment location to the point of evaluation is a very significant application factor in determining the estimated A-weighted sound pressure levels resulting from the operation of outdoor equipment in any installation. The distance factor is obtained from Table 4.

TABLE 1: EQUIPMENT LOCATION FACTOR

Equipment Location Factor.	Factor Value
a. Equipment on ground or roof or in side of building wall with *no* adjacent reflective surface within 10 feet (d greater than 10 ft)	0 dB
b. Equipment on ground or roof or in side of building wall with a *single* adjacent reflective surface within 10 feet (d less than 10 ft)	3 dB

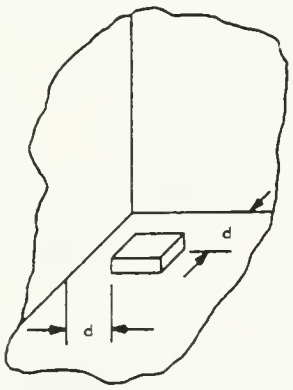


On Ground or Roof
Single Reflective Surface

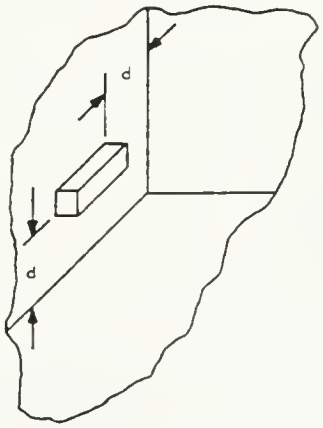


In Side of Building
Single Reflective Surface

c. Equipment on ground or roof or in side of building wall within 10 feet of *two* adjacent walls forming an inside corner (d less than 10 ft to both surfaces)	6 dB



On Ground or Roof
Two Adjacent Reflecting Surfaces



In Side of Building
Two Adjacent Reflecting Surfaces

I. *Equipment Location Factor* (continued)	Factor Value
d. Equipment on ground or roof or in side of building wall and between two opposite reflecting surfaces less than 15 feet apart	6 dB

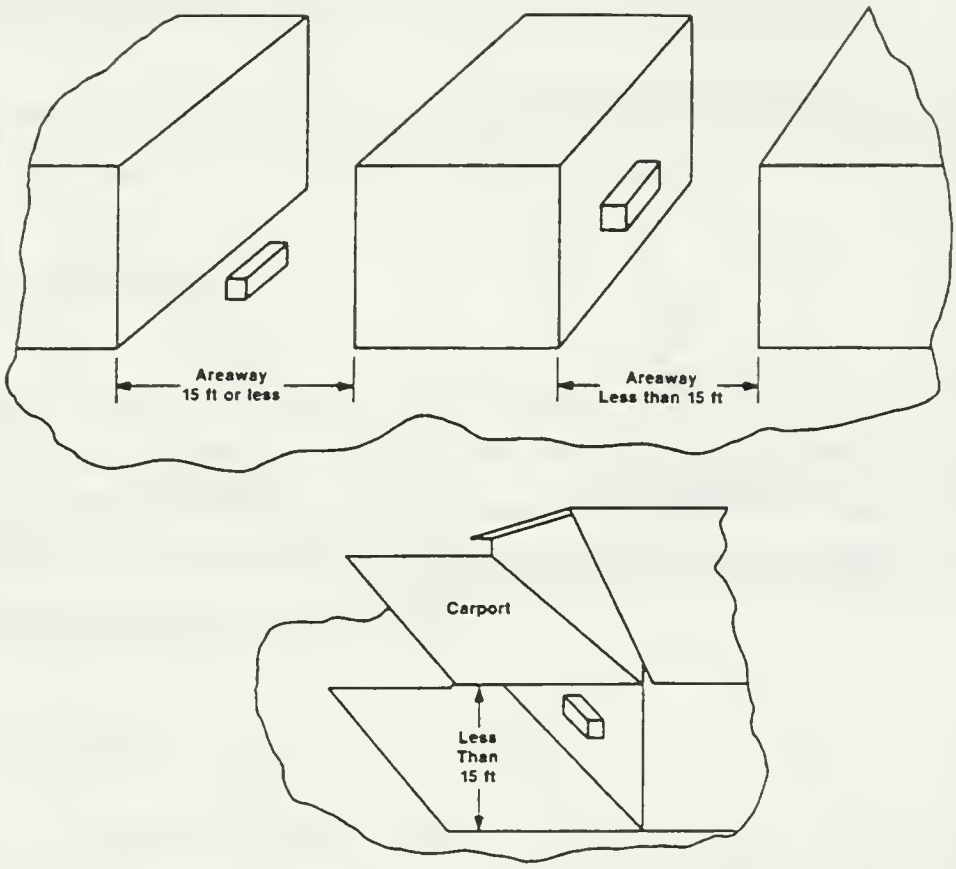
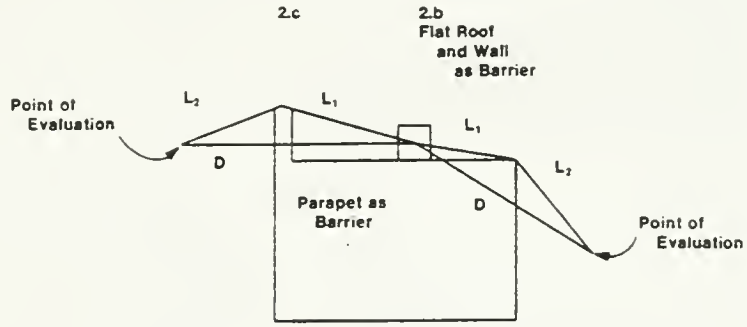
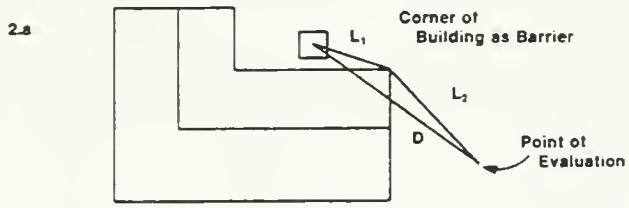


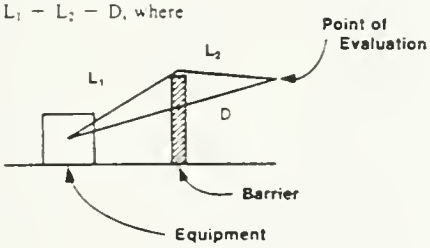
TABLE 2: BARRIER SHIELDING FACTOR

2. *Barrier Shielding Factor* (See Sketches, below). Sound reduction benefits can be gained when a solid structure obstructs the sound path. These structures could be:
   a. Corner of building
   b. Corner of flat roof and wall
   c. Parapet around flat roof
   d. Heavy continuous wall





$L = L_1 + L_2 - D$, where



L	Factor Value
0.5	4 dB
1	7 dB
2	10 dB
3	12 dB
6	15 dB
12	17 dB

$L_1 + L_2$ = distance in feet from equipment to point of evaluation around barrier (Use minimum $L_1 + L_2$ value)

D = Direct distance in feet from equipment to point of evaluation with no barrier. Determine D by layout sketch

TABLE 3: SOUND PATH FACTOR

3. *Sound Path Factor*	Factor Value
a. To a point of evaluation outdoors	0 dB
b. To room through open window(s) or open door(s)	10 dB
c. To room through closed single glass window(s) or door	17 dB
d. To room through closed double glass window(s) or solid wall	23 dB

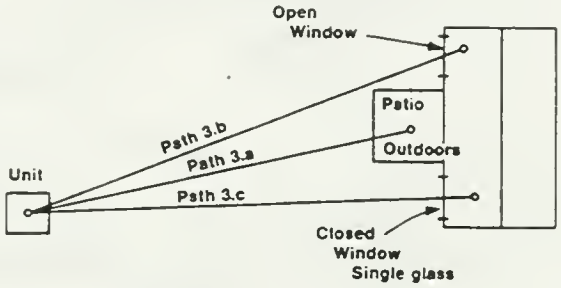


TABLE 4: DISTANCE FACTOR

Distance Factor		
(ft)	[m]	Factor Value (dB)
4	1.2	9.5
5	1.5	11.5
6	1.8	13.0
7	2.1	14.5
8	2.4	15.5
9	2.7	16.5
10	3.0	17.5
15	4.6	21.0
20	6.1	23.5
25	7.6	25.5
30	9.1	27.0
40	12.2	29.5
50	15.2	31.0
60	18.3	33.0
70	21.3	34.5
80	24.4	35.5
90	27.4	36.5
100	30.5	37.5
125	38.1	39.5
150	45.7	41.0
175	53.3	42.5
200	61.0	43.5
400	122.0	49.5

6.4 Procedure for Predicting Approximate Sound Pressure Levels of Multiple Units

Sound levels for multiple unit installations at any point of interest can be determined by combining the effects of each unit at the point of evaluation. The procedure for calculation of sound levels from multiple unit installations follows that used for single units except for the additional procedure used to combine sound levels.

The combined sound pressure level for all units is determined as follows:

(i) Determine the numerical difference between the largest and next largest sound pressure levels.

(ii) Using Table 5, find the proper value and add it to the larger sound pressure level. This new value is the combination of the two largest values.

(iii) Determine the numerical difference between this new value and the third largest sound pressure level. Again using Table 5, find the proper value and add it to the new value that was obtained between the two highest sound pressure levels.

(iv) Continue this combining procedure until the value to be added from Table 5 becomes 0.0 or until all numbers have been combined.

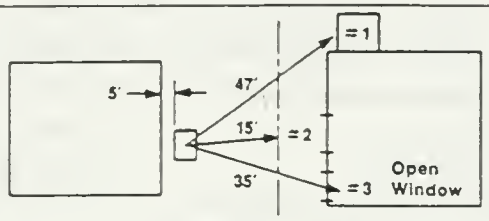
(v) The resulting single number represents the combined sound pressure level of all units at the point of evaluation.

TABLE 5: VALUES USED FOR COMBINING NUMBERS FOR MULTI-UNIT INSTALLATIONS

VALUES USED FOR COMBINING NUMBERS FOR MULTI-UNIT INSTALLATIONS	
Difference Between Numbers (dB)	Value to be Added to Larger Number (dB)
0 to 0.5	3.0
1.0 to 1.5	2.5
2.0 to 3.0	2.0
3.5 to 5.0	1.5
5.5 to 7.0	1.0
greater than 7.0	0.0

6.5 Examples of Calculation

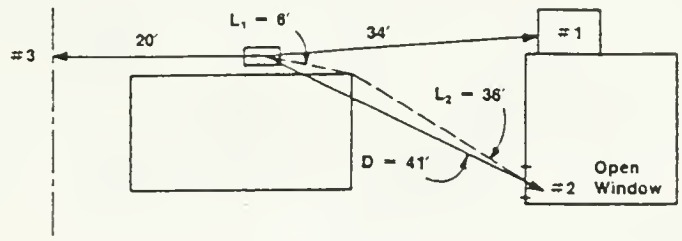
(i) Installation With No Barrier and One Reflective Surface



Sound Rating of Unit = 6.8

LINE	Distance from equipment to evaluation point { 1. 47 ft 2. 15 ft 3. 35 ft	EVALUATION POINTS		
		1	2	3
1	Record Sound Rating × 10	68	68	68
2	Equipment location factor (Table 1, Item 1)	3	3	3
3	Add Lines 1 and 2	71	71	71
4	Barrier Shielding Factor (Table 1, Item 2)	0	0	0
5	Sound Path Factor (Table 1, Item 3)	0	0	10
6	Distance Factor (Table 2)	31	21	28
7	Add Lines 4, 5 and 6	31	21	38
8	Estimated A-weighted sound pressure level (±5 dB) Subtract Line 7 from Line 3	40	50	33

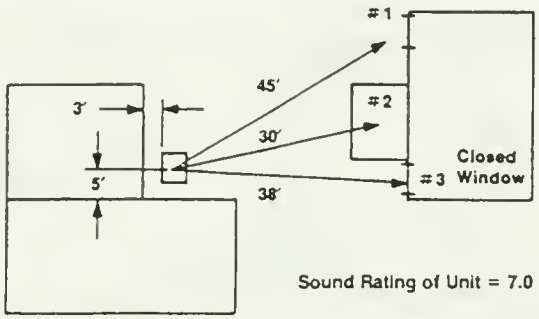
(ii) Installation with Barrier



Sound Rating of Unit = 7.0
$L = L_1 + L_2 - D$

LINE	Distance from equipment to evaluation point { 1. 34 ft 2. 41 ft 3. 20 ft	EVALUATION POINTS		
		1	2	3
1	Record Sound Rating × 10	70	70	70
2	Equipment location factor (Table 1, Item 1)	3	3	3
3	Add Lines 1 and 2	73	73	73
4	Barrier Shielding Factor (Table 1, Item 2)	0	7	0
5	Sound Path Factor (Table 1, Item 3)	0	10	0
6	Distance Factor (Table 2)	28	29.5	23.5
7	Add Lines 4, 5 and 6	28	46.5	23.5
8	Estimated A-weighted sound pressure level (±5 dB) Subtract Line 7 from Line 3	45	26.5	49.5

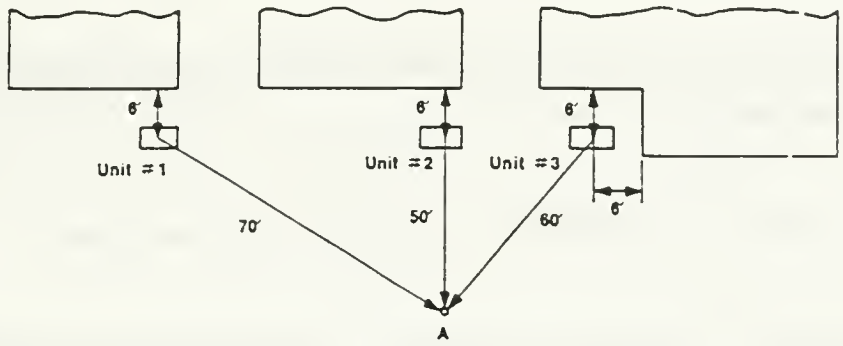
(iii) Installation With Two Reflective Surfaces



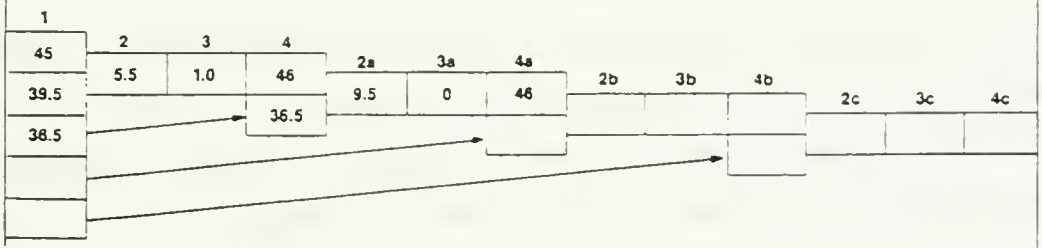
Sound Rating of Unit = 7.0

LINE	Distance from equipment to evaluation point { 1. 45 ft 2. 30 ft 3. 38 ft	EVALUATION POINTS		
		1	2	3
1	Record Sound Rating × 10	70	70	70
2	Equipment location factor (Table 1, Item 1)	6	6	6
3	Add Lines 1 and 2	76	76	76
4	Barrier Shielding Factor (Table 1, Item 2)	0	0	0
5	Sound Path Factor (Table 1, Item 3)	0	0	17
6	Distance Factor (Table 2)	30.5	27	29
7	Add Lines 4, 5 and 6	30.5	27	46
8	Estimated A-weighted sound pressure level (± 5 dB) Subtract Line 7 from Line 3	45.5	49	30

(iv) Multiple Units Installations



LINE	Distance from equipment to evaluation point { 1. 70 ft 2. 50 ft 3. 60 ft	UNITS		
		1	2	3
1	Record Sound Rating of Units × 10	68	68	72
2	Equipment location factor (Table 1, Item 1)	3	3	6
3	Add Lines 1 and 2	71	71	78
4	Barrier Shielding Factor (Table 1, Item 2)	0	0	0
5	Sound Path Factor	0	0	0
6	Distance Factor (Table 2)	34.5	31.5	33
7	Add Lines 4, 5 and 6	34.5	31.5	33
8	Estimated A-weighted sound pressure level (±5 dB) Subtract Line 7 from Line 3	36.5	39.5	45



9	Estimated A-weighted sound pressure level at Point A (±5dB)	46

Reproduced by permission from ARI Standard 275-84

(iv) Multiple Units

(a) Calculate estimated A-weighted sound pressure level for each unit.

(b) List estimated level for each unit in column 1 starting with the largest number first and second largest next, etc.

(c) Enter in column 2, the difference of values between the two largest.

(d) Enter in column 3, the value to be added to the largest value from Table 5.

(e) Enter the new value in column 4 below.

(f) If there are more than two units, repeat above procedure (c) through (e), starting in column 2(a).

Continue until a single value exists. Note that the third entry in column 1 is transferred to column 4 as indicated by the arrow, the fourth entry to column 4(a), etc.

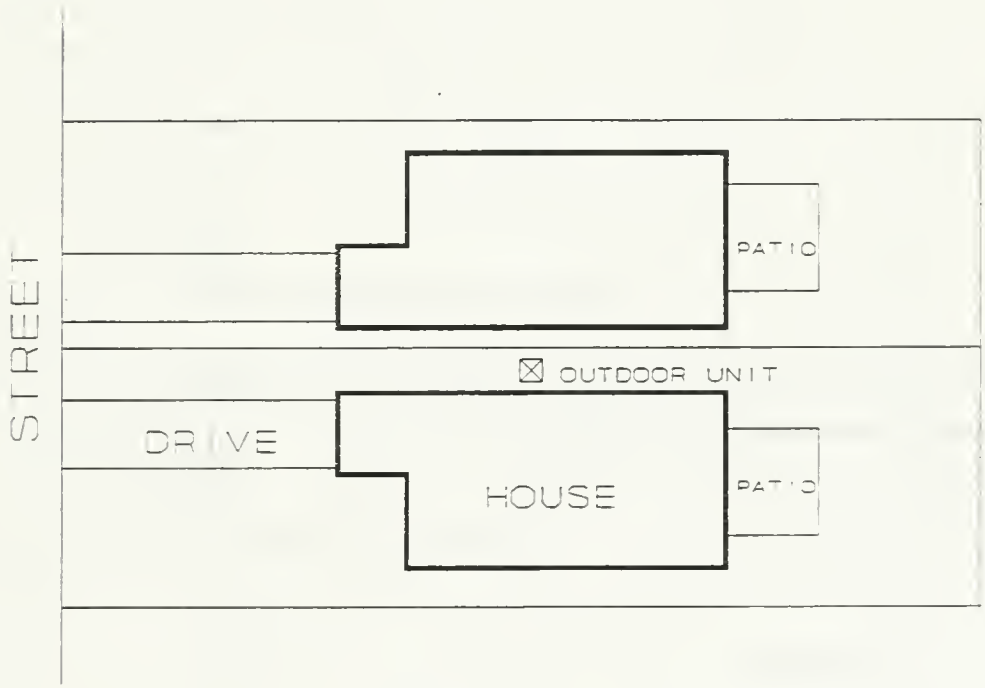
7. INSTALLATION GUIDELINES

The majority of noise problems resulting from currently installed residential air conditioners or heat pumps would not exist if the installer and home owner had analyzed the owner's property to determine the location which produced the least noise impact at adjoining properties. The sections that follow outline some simple "do's" and "don'ts" when it comes to installing air conditioners or heat pumps.

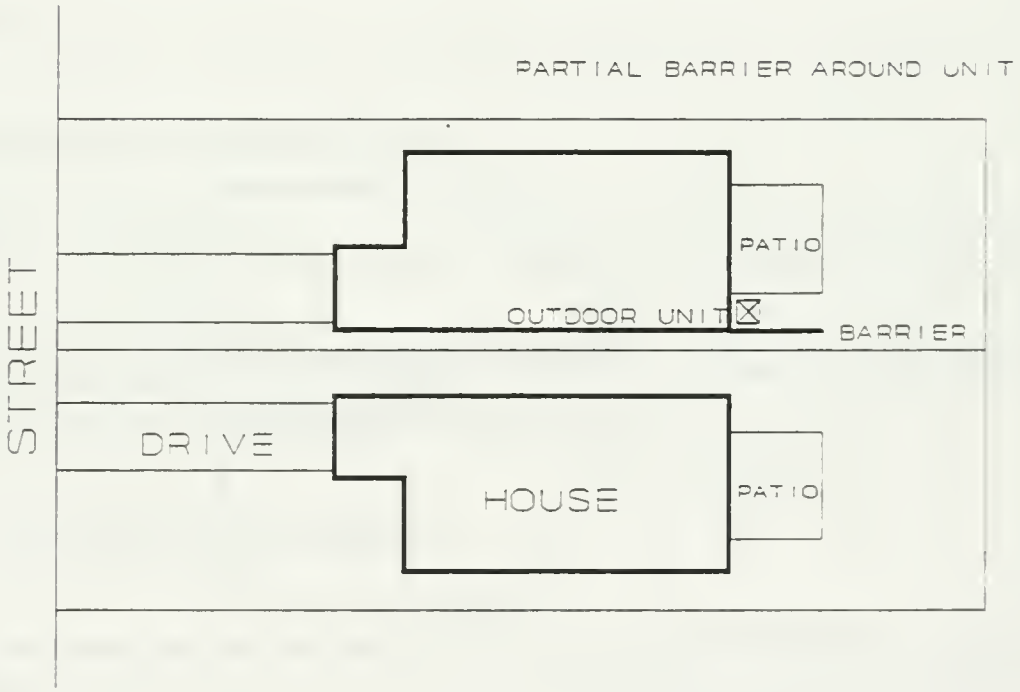
7.1 Do's and Don'ts when Installing Residential AC/HP Units

(a) Do's:

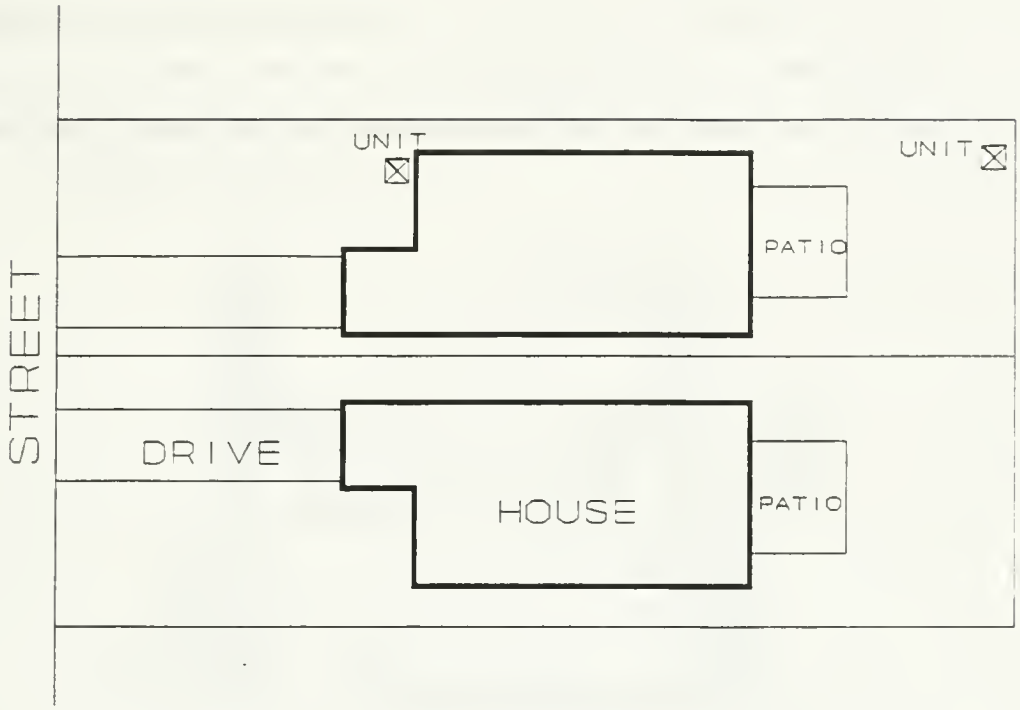
(i) The unit should be positioned such that there are no windows or openings along the direction of sound wave propagation. The solid wall of the neighbour's house in the diagram below acts as a shield to the noise emitted by the unit.



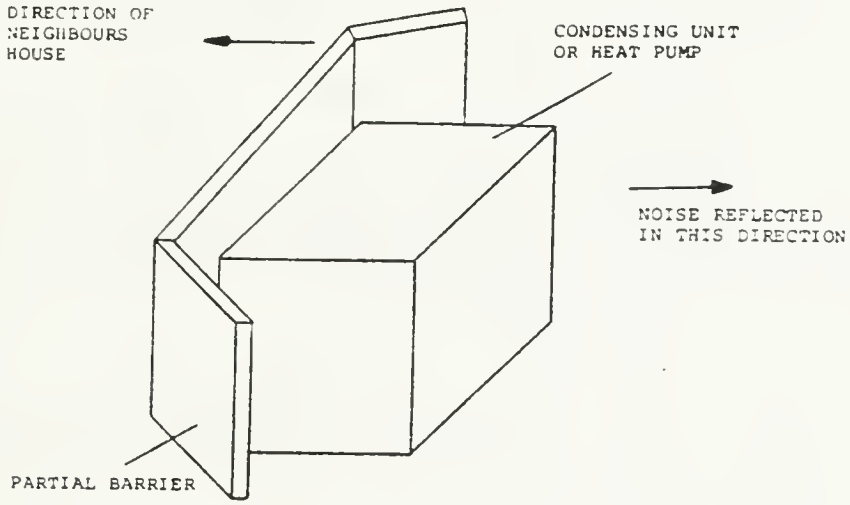
(ii) A partial barrier can be provided for the unit in order to reduce the noise that would otherwise be radiated towards the neighbour's house. Weatherproof absorptive treatment can be provided with the barrier to reduce the noise reflected from the house wall. The sketch below shows the use of the barrier.



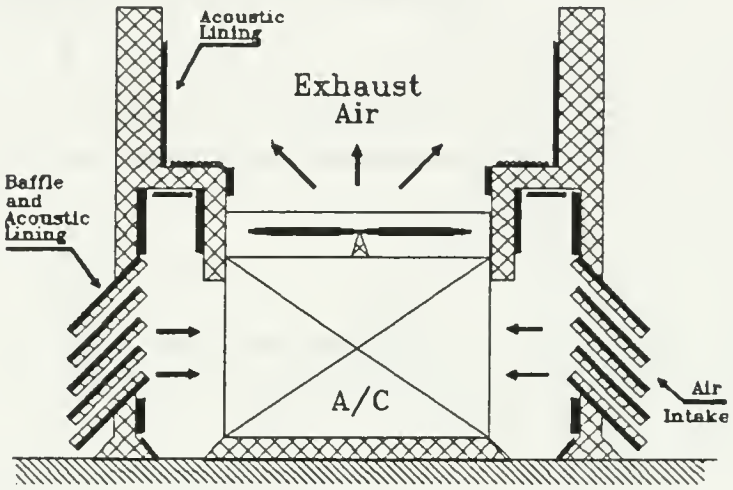
(iii) If possible, an alternative is to place the unit in the front yard or backyard, as shown below, where it would be away from the neighbour's patio.



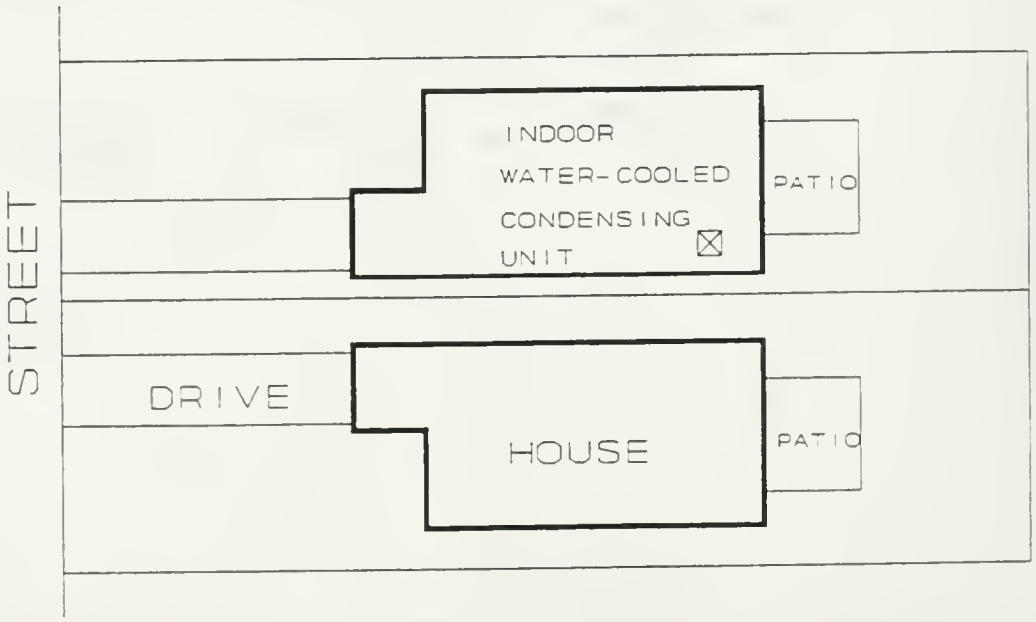
(iv) The following sketch shows a partial barrier which can also be used to deflect noise away from the neighbour's house. Such barrier will only be effective for horizontal discharge units. Care must be taken so that the airflow into and out of the unit is not impeded. For more details refer to section 8.2.



(v) An acoustic enclosure, as shown below, can be used to greatly reduce the noise radiated by the unit. The manufacturer of the unit or a specialist on enclosures for air conditioning equipment should be consulted. For more details refer to section 8.6.

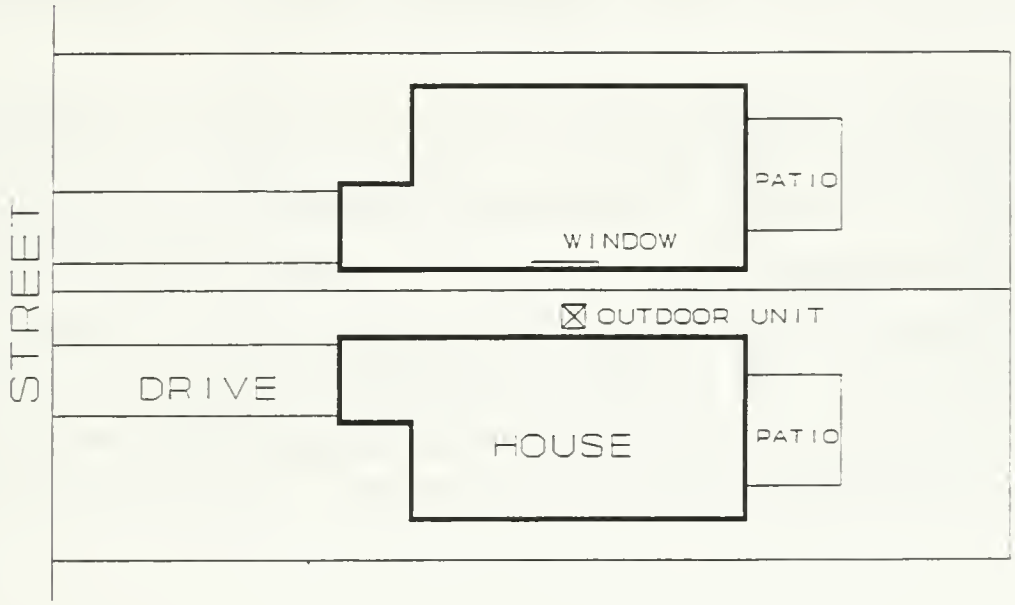


(vi) If possible, use a water-cooled condensing unit located inside the house (where local municipal by-laws permit).

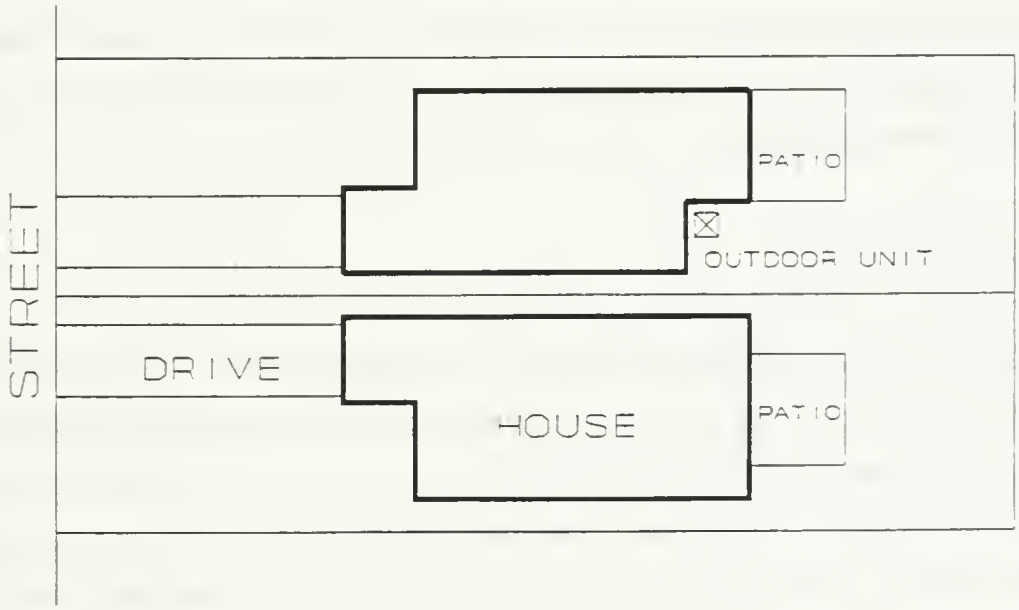


(b) Don'ts

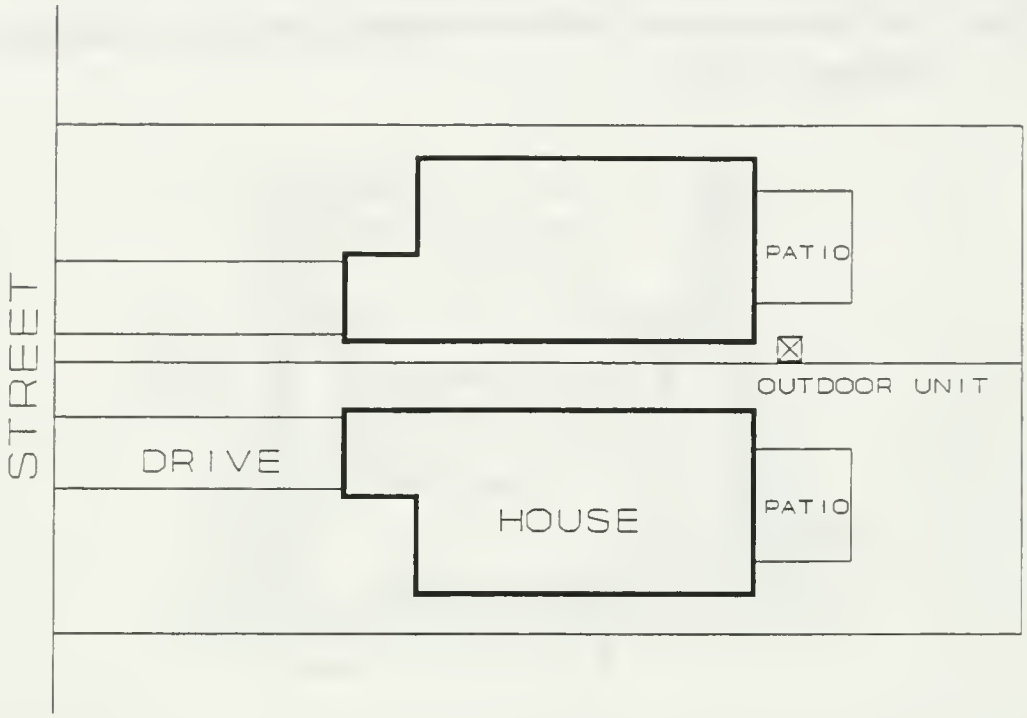
(i) Do not place the unit where the radiated noise may be transmitted through the neighbour's windows.



(ii) Avoid locating the unit close to hard reflecting surfaces.



(iii) Avoid locating the unit close to neighbour's outdoor living area or patio.



8. NOISE CONTROL TECHNIQUES

A detailed description of conventional abatement techniques, including proper equipment selection, application of acoustical barriers and enclosures as well as the use of indoor units and relocation is given in the following subsections.

8.1 Equipment Selection

ARI publishes a Directory of Certified Unitary Air Conditioners and Heat Pumps. The directory lists all eligible models of air conditioners and heat pumps produced by manufacturers participating in the ARI certification program. Information in the directory includes data on cooling cost, thermal capacity and sound rating in bels for each model. The sound rating, as defined in the ARI Standard 270-84, is an indicator of the sound power level of the equipment; the lower the sound rating, the lower the sound

power emitted by the outdoor equipment. The great majority of sound ratings identified in the directory for the respective models fall between 7.2 and 9.0 bels.

Some manufacturers produce AC/HP equipment with comparatively low sound rating; and the installer should use the sound rating information to full advantage when selecting an air conditioner unit.

Table 6 provides a selection guideline on maximum sound rating for units operating under various installation conditions. The selection of a unit by following the guidelines in the table will ensure compliance with the recommended sound level limit at the point of reception in a quiet residential area. It should be noted that some installations are not feasible with units presently available on the market, unless additional noise control measures are included. A properly designed acoustic barrier in the form of a garden shed, property line solid fence, or an acoustic enclosure will typically provide 10 dB reduction in sound levels at the point of reception. The inclusion of these measures in the proposed installation will allow selection of units with sound rating values higher than those recommended in Table 6.

For individual installations proposed in areas with high background sound levels, such as locations close to major transportation corridors or industrial and commercial establishments, requirements for the maximum sound rating of AC/HP units are less stringent. For example, in an area where the background sound level is 60 dBA, a unit can be selected with sound rating of one (1.0) bel and two (2.0) bels higher than those listed in the section of Table 6 referring to Leq=50 dBA limit, for installations without and with additional noise control measures (i.e. barrier or enclosure providing 10 dB reduction) respectively.

The Air Conditioning Device Installation Check List for Noise Control in Urban Areas included in Appendix B provides a step-by-step procedure for selection of the AC/HP unit sound rating for a wide range of installation conditions and the area sound level limits.

TABLE 6: RECOMMENDED MAXIMUM ARI SOUND RATING VALUES FOR AC AND HP UNITS IN BELS.

NOTE: After 1991-12-31 and before 1995-01-01 the Maximum ARI Standard Sound Rating acceptable in Ontario is 7.6 bels	INSTALLATION CONDITIONS (as defined in Table 1)		
	a) Equipment on ground or roof or in side of building wall with no adjacent reflective surfaces within 3 m.	b) Same as a) but with a single adjacent reflective surface within 3 m. (the unit located near wall of building.)	c) Same as a) but with two adjacent walls forming an inside corner, or between two opposite reflective surfaces less than 5 m apart.
Distance from the unit to receptor in meters	Sound Rating required to ensure Leq = 45 dBA Limit (Class 2 Area as defined in Annex to NPC-216)		
5.0**	6.8	6.4*	6.2*
8.0	7.2	6.8	6.6*
12.5	7.6	7.2	7.0
20.0	8.0	7.6	7.4
	Sound rating required to ensure Leq = 50 dBA Limit (Class 1 Area as defined in Annex to NPC-216)		
4.0**	7.0	6.8	6.4*
6.3	7.4	7.2	6.8
10.0	7.8	7.6	7.2
16.0	8.2	8.0	7.6
	Sound rating required to ensure Leq = 55 dBA Limit (Urban locations where unit was a mandatory requirement for noise control in new land use developments)		
4.0**	7.6	7.2	7.0
6.3	8.0	7.6	7.4
10.0	8.4	8.0	7.8

* Sound rating values for units presently not yet available on the market.

** Distances from the unit to receptor shorter than 4 m are not realistic and, therefore, are not included in the Table.

NOTE: The above maximum sound rating values can be increased in situations where an acoustic barrier or other means reduce the sound level to the acceptable limit.

8.2 Use of Barriers

Barriers, if properly installed, can be the most cost-effective means of noise reduction. Common barrier materials include steel, plywood and concrete. General guidelines for barrier walls include the following:

(i) Place barriers as close to the source as possible without restricting airflow to/from the unit. This will ensure the deflection of most of the sound away from the evaluation point. Care must be taken not to restrict the airflow of the unit as this would lead to a decrease in unit efficiency. The manufacturer should be consulted on minimum distance requirement.

(ii) Barriers must be free of holes, gaps, cracks, etc. Sound would be transmitted through the wall if this condition is not met.

(iii) Single barriers generally do not require sound absorbing surfaces. Absorptive treatment on the source side of the barrier makes only a minor improvement in sound radiation and is generally not cost-effective.

(iv) In situations where house walls will reflect sound back at the barrier, the effectiveness of the barrier shielding will be significantly reduced. To remedy this, wall surfaces facing the unit should be covered with sound absorbing material.

(v) One of the simplest and most effective shielding structures may be a suitably located garden shed.

8.3 Relocation

Relocating the air conditioner is another possible method of reducing the noise in a specific area or direction.

(i) Relocating the Outdoor Condensing Unit or Heat Pump.

As the condenser units produce a continuous, steady sound while operating, the owner will most likely locate the unit as far as possible from his or her bedroom or outdoor living area. This often means that the unit is placed near the adjacent residential property which may result in noise impact and annoyance to the neighbour.

Before permanently installing the unit, a location should be selected that will minimize the noise impact at nearby property lines. There are several installation locations that should be avoided due to their ability to actually increase the noise level. Described briefly, they are a) within 10 feet of a wall; b) within 10 feet of two adjacent walls (such as a corner); and, c) within 15 feet of two opposite walls (such as between two houses). A list of suitable locations were highlighted earlier in Section 7.1.

To assist in determining the potential noise levels at nearby property lines, the installer is referred to Section 6.2, "Sound Level Calculation Procedure" developed by the Air-Conditioning and Refrigeration Institute (ARI). If results of the calculation (following the above procedure) indicate that operation of the unit is in violation of local noise by-law or Ontario MOEE noise criteria, the owner should provide noise abatement measures to reduce sound levels and ensure compliance with environmental noise criteria, or purchase a quieter unit.

(ii) <u>Relocating Window Unit</u>

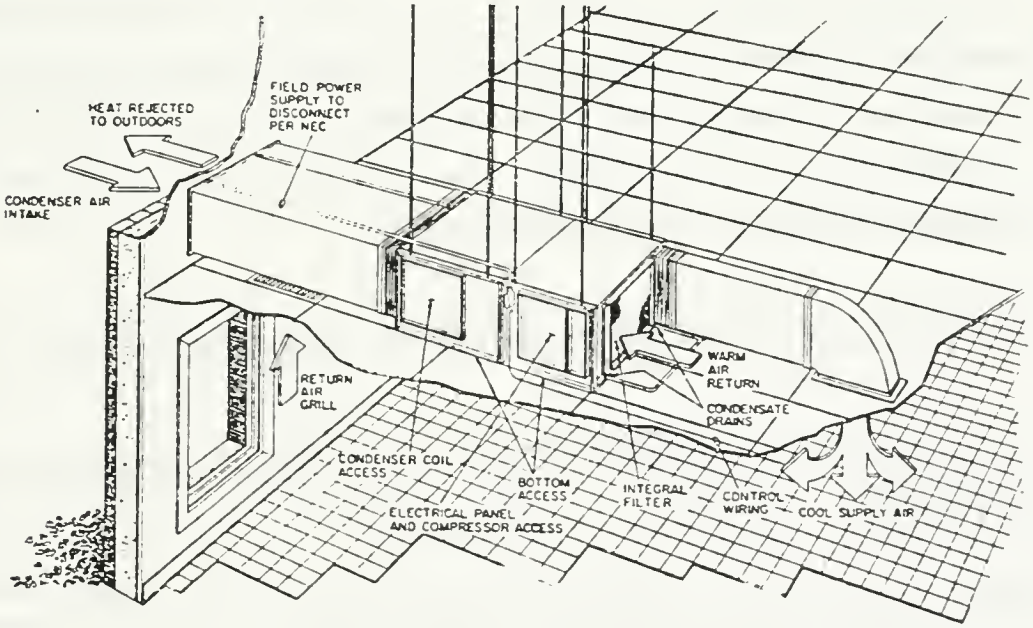
One method of reducing the noise from a window unit is simply to move the unit to another window. This is easier said than done since moving the air conditioner from the original location may not be possible without reducing cooling, which was the reason for having the air conditioner in the first place. If relocation of the unit is not a feasible solution, other measures such as acoustical barriers or an enclosure should be designed and implemented, to reduce noise levels and to eliminate or minimize noise impact.

8.4 Indoor Units

The majority of AC/HP equipment available on the market falls into two categories: packaged and split systems. In packaged systems the components are factory assembled into an integrated package which is either window mounted or in the form of self-contained package located outside (with the indoor air supplied to the unit and then returned through ducts).

In the split system, the indoor coil is located inside the residence and is connected through tubing lines to an outdoor coil (condenser).

Recently, a new type of AC/HP system; a horizontal indoor single package unit has been developed and is commercially available. It is a combination of heating/cooling system designed to be used in ceiling spaces of stores, offices and large houses. The unit is hung from the joists and the condenser section is ducted to the exterior surface as shown in the sketch below.



Reproduced by permission from Carrier Corporation

Due to built-in design, the backyard is protected from the condenser noise.

8.5 AC/HP Unit Maintenance

Proper maintenance of the AC/HP unit will not only ensure efficient operation and durability, but it also will help to minimize the unit's noise emission.

It is strongly recommended that, at the beginning of each cooling season the condenser unit, evaporative coil and indoor unit all be subjected to check-ups and adjustments as specified in the manufacturer's maintenance schedule.

Extended manufacturer's warranties are available to facilitate such check-ups and adjustments by qualified personnel.

8.6 Enclosures

A complete enclosure can provide up to 10 decibel noise reduction provided it is correctly designed and built. Enclosures reduce noise impact by absorbing part of the source sound energy and re-directing some of the remainder to minimize the amount reaching the noise sensitive locations. However, due to potential effects on the AC/HP unit performance, an enclosure should be considered as a last resort.

Enclosures can be made of sheet metal, plywood and an absorptive liner.

Several construction-assembly details should be remembered when designing and building an enclosure:

(i) The enclosure must be designed to provide adequate flow separation between inlet air and discharge air. An appropriate detailed technical evaluation of airflow must be carried out at the initial stage of the enclosure design. An enclosure which is not properly designed may result in reduction of AC/HP unit efficiency, leading to a possible break-down of the unit and voidance of the manufacturer's warranty.

(ii) There should be no cracks or holes in the condenser casing (between panels or at the intersection of panels at corners). Gasket material or silicone sealant application will prevent "sound leaks".

(iii) Panels should be "floating" on a foam gasket material such that they do not make physical contact with each other or the unit frame, except through mounting screws.

(iv) Absorptive duct liner should be securely fastened to the inside of the enclosure on 12" centres using wood screws through washers or nails driven through a 2" square piece of sheet metal.

(v) The enclosure must not touch the unit; otherwise any noise from this unit will be transmitted to the enclosure.

(vi) The enclosure roof, if provided, should be designed to eliminate water penetration into the absorptive liner.

(vii) An open top enclosure type should not be used for HP unit to avoid snow build-up.

9. PROVINCIAL GUIDELINES, CRITERIA AND MUNICIPAL BY-LAWS REGULATING A/C NOISE

Almost every municipality in Ontario enacted some form of a nuisance by-law, designed to restrict unnecessary honking of horns, driving a car with a faulty muffler, loud or boisterous parties, and other activities which generally could be classified as disturbances of the peace. Community reaction to sound of the continuous nature, such as one generated by an AC or HP unit, is far more subtle than these nuisance by-laws have been able to cope with, since, from a legal point of view, such continuous type noise problems are concerned with invasion of privacy (see reference 3) rather than the question of disturbing the peace.

Early ordinances mentioning AC devices were of two specific types: one referred only to the location of outdoor equipment on the property with reference to property lines, the other referred to sound level limits in dB, either on the "A"-weighted scale or by octave-bands.

AC noise ordinances based on acceptable sound level limits have been enacted in a large number of cities and communities in North America. These limits expressed in terms of maximum A-weighted sound levels (except traffic) at a residential boundary range from 35 dBA to 60 dBA.

In 1970, an Air Conditioner Noise Committee was established in Ontario composed of representatives of the Heating, Refrigerating and Air Conditioning Institute of Canada, Ontario Hydro Commission, National Research Council, University of Toronto, Borough of Etobicoke Building Department and other agencies, to review regulatory aspects of AC noise, to discuss future trends in equipment modifications, measurement standards, as well as installation and noise impact assessment procedures. A report prepared by the Committee included a number of recommendations related to standards and guidelines development, and proposed gradually lower maximum acceptable outdoor sound levels (measured at lot line), due to AC units which would represent a reasonable national standard acceptable to the various levels of government. The recommended levels, to be in effect by 1977, were 50 dBA and 45 dBA day and nighttime respectively. A separate limit of 35 dBA was set for indoor noise levels measured in bedroom areas.

Based on the findings and proposals of the Committee, air conditioner noise criteria were incorporated in the 1978 Model Municipal Noise Control By-law, developed by the Ontario Ministry of the Environment. These criteria are part of a comprehensive option of the Model Municipal Noise Control By-Law, and specific sound level limits for AC devices are referred to in Technical Publication NPC-116, Residential Air Conditioners. The essence of these criteria is that the emission of sound from an AC unit should not result in sound levels in excess of 45 dBA and 50 dBA limits for central AC units and window or through-the-wall AC units respectively, when measured at the point of reception on the adjacent residential property. Should the existing ambient level (due to road traffic) be higher than these limits, it will constitute the criterion limit (the less restrictive provision prevails) for that hour.

In addition to sound level limits, sound emission standards for AC/HP units were to be developed for future inclusion in the Ministry's noise criteria under Section 4 of the NPC-116 publication. Development of these emission standards was to be predicated on the manufacturer's co-operation in producing, through design and technological improvements, a significant reduction in the noise levels of AC & HP equipment.

More recently, the construction of new housing, especially in areas of high noise due to surface transportation has resulted in a requirement for residential units to achieve a suitable indoor noise environment with closed windows. Due to close proximity of residential lots, typical for new housing developments, the use of AC/HP results more often in increased noise levels at adjacent residential properties with consequent complaints to the local Municipalities.

Concerns have been raised by the manufacturers and Municipal authorities that the Ministry's noise acceptability criteria for AC/HP equipment were too restrictive to allow for installation of units presently available on the market, in a given layout of closely spaced residential lots. In response to these concerns, the Ministry of the Environment with the co-operation of the Heating Refrigerating and Air Conditioning Institute of Canada, Ontario Home Builders' Association and the Association of Municipalities of Ontario organized in 1987 a Symposium on Air Conditioner Noise. The delegates to the Symposium represented a broad cross-section of the interest groups which included the manufacturers and installers of the AC/HP units, acoustical consultants, municipal planners, bylaw officers and the residential users of AC/HP (see reference 26).

In accordance with the recommendations and resolutions of the Symposium, an Advisory Committee on Air Conditioner Noise has been formed to examine and make recommendations on uniform, practical and enforceable measures leading to the solution of the noise problem identified during this symposium. A number of technical sub-committees have been set up to work on the specific areas of interest such as; manufacturing standards, installation guidelines, training opportunities, building code requirements and jurisdictional constraints.

Also sponsored by the Advisory Committee, a survey of both sound levels and subjective attitudes to residential AC/HP noise was initiated jointly by the National Research Council and the Ontario Ministry of the Environment in 1989. The principal objectives of this survey were:

a) to quantify the relationship between subjective response to neighbour's AC/HP unit noise and the measured noise levels of these units;

b) to provide information to support the setting of acceptable limits for outdoor AC/HP noise levels;

c) to examine how local ambient noise and ownership of an AC/HP influence adverse reactions to the AC/HP noise;

d) to consider the influence of other non-noise factors on adverse reactions to neighbour's AC/HP noise;

e) to compare measured AC/HP noise levels with predictions based on the ARI 275-84 procedure.

The survey was carried out in the Metro Toronto area, and both subjective and objective data were successfully obtained for 550 respondents. A final report on survey findings (see reference 25) was released in 1991.

Tables 216-1 and 216-2 in Appendix A represent conclusions of the Advisory Committee on the issue of acceptability criteria for AC/HP noise.

(a) Sound Level Limits

The recommended specific levels shown in Table 216-2 are expressed in terms of the hourly equivalent energy level (Leq), and apply to receptor locations in Class 1 and Class 2 areas, as defined in Sec. 3 of Publication NPC-216. A separate limit (for central AC/HP devices) applies

to receptor locations in Class 1 areas where the unit was a mandatory requirement for noise control in new land use developments.

To address situations where AC/HP units may be operated in an area of a relatively high ambient noise, a pre-emption or general limits have been included in Table 216-1, setting the existing ambient sound level due to road traffic, higher than the limits in Table 216-2, as the criterion of acceptability for AC/HP unit operation. The general limits are increased by 5 dB for any hour between 07:00 and 21:00.

Verification of compliance by the AC/HP units with the guideline sound level limits can be accomplished through measurements using a properly calibrated sound level meter which meets the required standard specifications. Details of the instrument specification are included in Section 3 of the Technical Publication NPC-102, Instrumentation (see reference 12).

The measurements should be carried out outdoors at a closest point of reception on residential property adjacent to the AC/HP unit. The measurement may also be required at a point of reception in plane of an open window facing the AC/HP unit to ensure that sound levels at noise sensitive indoor spaces in a residence adjacent to the source are not in excess of the guideline limits. Details of the measurement procedure are included in Section 3 of the Technical Publication NPC-103, Procedures (see reference 12)

An assessment of ambient sound levels can be made using either measurement or calculation method. The one hour Leq of road traffic should be obtained in accordance with the procedure described in Section 4 of the Technical Publication NPC-103, Procedures. Alternately, the one hour Leq of road traffic may be calculated on the basis of traffic flows observed on the contributing roads, within one hour of the period when the AC/HP noise is measured. The procedure for calculation of one hour Leq at the point of reception is described in the "Ontario Road Noise Analysis Method for Environment and Transportation". (see reference 24)

The Air Conditioning Device Noise Investigation Checklist included in Appendix C provid step-by-step procedure for measurements of the AC/HP unit noise, ambient noise, and the fo of reporting measurement results, adjustments and conclusion of the measurement survey

b) Sound Emission Standards

The maximum acceptable ARI Standard Sound Ratings shown in Table 216-4 are se accordance with the date of the manufacture. Two emission limits; 8.0 and 7.6 bels specified for AC/HP units built during 1991, and during 1992, 1993 and 1994 respectively. units are sized at less than 38,900 BTUH capacity. The emission limits projected after 1994 under discussion with the industry to assess the feasibility of reduction.

The sound level limits, and sound emission standards are included in the revised Technical Publicat NPC-216 representing a regulatory tool in controlling AC/HP noise. The enforcement of these nc bylaw provisions is a municipal responsibility in the province of Ontario.

10. REFERENCES

1. W. Scott Bayless, "Noise Considerations in the Application and Installation of Outdoor Air Conditioning Equipment", ASHRAE Journal, April 1967.

2. W.W. Blasier, Jr., "A Field Measurement Study The Sound Levels Produced Outdoors by Residential Air Conditioning Equipment", ASHRAE Journal, May 1967.

3. A.E. Meling, "Community Noise Ordinances", ASHRAE Journal, May 1967.

4. Borough of Etobicoke Planning Department, Z-113, "Report Regarding Air Conditioner Noise Regulations and General Noise Control", April 1972.

5. D.W. Sutton, "Air Conditioner Noise; An Environmental Problem", Ontario Ministry of the Environment, April 1974.

6. National Noise and Vibration Control Conference, "Proceedings of the Technical Program", March 1976.

7. D.N. May, "A Noise Enclosure for a Residential Central Air Conditioning Unit", Noise Expo Proceedings, 1976.

8. D. Schenk, P. Zorazella and W. Richards, "Measurement and Feasible Reductions of Air Conditioner Noise", August 1976.

9. L.G. Kende, "10 dB Noise Reduction of Window Air Conditioners", Ontario Ministry of the Environment, 1977.

10. Environmental Protection Agency, "Techniques for Controlling Noise from Residential Heat Pumps", 1977

11. Central Mortgage and Housing Corporation, "Site Planning Criteria", September 1977.

12. Ontario Ministry of the Environment, "Model Municipal Noise Control By-Law, Final Report", August 1978.

13. Acoustical Society of America, "Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms", ASA Standard 11-1980, ANSI S1.31-1980.

14. Acoustical Society of America, Precision Methods for the Determination of Sound Power Levels of Discreet-Frequency in Narrow-Band Noise Sources in Reverberant Rooms", ASA Standard 12-1980, ANSI S1.32-1980.

15. Environmental Protection Agency, "An Evaluation of Strategies to Control Noise from A Conditioning and Refrigeration Condensing Units", December 1981.

16. R.G. Harold, "ARI Sound Rating and Certification of Residential Outdoor Air Condition Units", Trane Company, 1982.

17. Canadian General Electric, "Noise Reduction Schemes", March 1983.

18. Ontario Ministry of the Environment, "Heat Pumps: Circumstances Compel Application c Century-Old Principles", May 1983.

19. Air Conditioning and Refrigeration Institute, "Standard for Application of Sound Rated Outdoo Unitary Equipment", ARI Standard 275, 1984.

20. T. Ahmed, C. A. Krajewski, "Air-Conditioner and Heat-Pump Noise. Installation Assessmen and Abatement Guidelines", Ontario Ministry of the Environment, 1985

21. Air Conditioning and Refrigeration Institute, "Standard for Sound Rating of Outdoor Unitar Equipment", ARI Standard 270, 1984.

22. Air Conditioning and Refrigeration Institute, "Directory of Certified Unitary Air Conditioners. Unitary Heat Pumps and Sound Rated Outdoor Unitary Equipment", 1989.

23. Canadian Acoustics, "Enclosures to Reduce Noise from Heat Pumps: Four Case Studies", July 1985.

24. Ontario Ministry of the Environment, "Ontario Road Noise Analysis Method for Environmen and Transportation" (ORNAMENT), 1988.

25. J.S.Bradley, J.D. Quirt, "Final Report, Survey of Outdoor Air Conditioner Noise", National Research Council, Institute for Research in Construction, Report No. CR-5954.2 (1991)

26. Ontario Ministry of the Environment, "Proceedings of the Symposium on Air Conditioner Noise Held November 24, 1987", ISBN NO. 0-7729-3740-0

APPENDIX A

RESIDENTIAL AIR CONDITIONING DEVICES.*

PUBLICATION NPC-216

ONTARIO MINISTRY OF ENVIRONMENT AND ENERGY

* The contents of this document are unchanged from the original publication "Residential Air Conditioning Devices, Publication NPC-216, October 1993" (ISBN 0-7778-0100-0).