New housing and airport noise

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CMHC
Canada Mortgage and Housing Corporation

SCHL
Société canadienne d'hypothèques et de logement

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Canada

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Minister

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New Housing and Airport Noise
A supplement to the *Site Planning Criteria*

Contents

Section A
Introduction

1. Public concern
There is a growing awareness of the noise problems associated with airport operations due to an increase in air traffic and the development of land near existing airports. Public concern about aircraft noise, as with other environmental problems, manifests itself in an increasing number of complaints and in growing public debate.

2. Land-use control
Municipal, Provincial and Federal Governments are involved in the ownership and operation of airports and in the control of land use and development of adjacent areas. Canada Mortgage and Housing Corporation has no authority to control the use of land for residential purposes — such authority lies with the provinces and municipalities. It is the responsibility of these governments to establish comprehensive compatible land-use plans for communities where aircraft noise will affect development. It is hoped that the criteria used by the Corporation to define the recommendations contained in this publication will be given consideration in the preparation of such plans.

3. CMHC's general policy
As a matter of general policy the Corporation wishes to draw attention to problems associated with aircraft noise; to support methods which seek to protect residential areas against the effects of aircraft noise; to encourage the cooperation of all levels of government to develop ways of alleviating the problems associated with such noise; to discourage the construction of new residential development on sites subject to some noise exposure at a lower level.

4. CMHC's involvement
The Corporation's involvement is related to the security of its financing and to the quality of housing conditions encouraged by its financial support.

4.1 Market housing
Builders should be aware that this document is advisory in nature. There are no mandatory requirements to obtain NHA insurance.

4.2 Social housing
For public, non-profit and cooperative housing, where CMHC is providing either direct or subsidy financing, the Corporation has decided to use a number of the recommendations detailed in this document as mandatory standards. For these social housing projects the following policies are applicable.

4.2.1
- The Corporation will apply the following policy to the Noise Exposure Forecast (NEF) contour maps it has prepared (See Section D.1)

4.2.1.1
- in the upper zone, Social Housing projects shall be denied financing under the National Housing Act

4.2.1.2
- in the intermediate zone, Social Housing projects shall be denied financing under the National Housing Act unless adequate sound insulation is provided, and

4.2.1.3
- in the lower zone, the provision of adequate sound insulation is recommended. Social Housing projects shall be denied financing under the National Housing Act in the upper third of this zone, i.e. between 28 and 30 NEF, if the sound insulation proposed is substantially below that considered to be adequate.

4.2.2

- Where general aviation contours are used (See Section D.2) the Corporation's policy outlined in 4.2.1 above will apply.

4.2.3

- Where specific forecasts are not available for military airports, the "box" contours defined in Section D.2 and illustrated in Figures 6a and 6b will be used, and financing under the National Housing Act will not be available for Social Housing projects within the area defined by the box.

4.2.4

- For other types of airports (See Section D.3) the Corporation will consider the individual circumstances applicable in each case. In determining its requirements, the Corporation will, if necessary, obtain the advice of Transport Canada and the National Research Council.

4.2.5

Adequate sound insulation

- Where noise exposure factors are between 25 and 35 NEF inclusive, the Corporation recommends or requires adequate sound insulation in new dwellings (See Section E.1).
- All the appropriate components indicated in Tables A to D are the minimum acceptable to the Corporation (See Section E.2e).
- The Corporation requires alternative means of ventilation (See Section E.3).
- The Corporation recognizes there are other and more detailed methods of calculating sound insulation, and substantiated proposals based upon such other methods may be acceptable to the Corporation in lieu of proposals adhering strictly to the method of calculation outlined in this publication.

Section B

The noise problem near airports: its evaluation

1. General

Individual reaction to noise, other than noise-induced hearing loss, is subjective and varies from person to person. A noise offensive to one person might not be so to another because in assessing his annoyance the individual takes into account many factors, including intensity, frequency of occurrence, duration and level of background sound. Because of varied individual reactions to noise, any requirements designed to deal with the problems it causes have to be based on the viewpoint of the "reasonable" or "average" person.

Aircraft noise can disturb sleep, privacy, rest and communication and in so doing may be considered potentially harmful to health. The long-term cumulative impact of aircraft noise on communities in the vicinity of airports, from the standpoint of causing mental or physical illness, remains to be fully evaluated.

From the weight of present evidence, Health and Welfare Canada considers that the expected noise levels in areas not exceeding 35 NEF will not cause mental or physical illness or permanent loss of hearing. However, over the 35 NEF level the Department considers that there is some likelihood of detrimental health effects (See Bibliography No. 17).

One of the most effective alleviations of the problem of aircraft noise could undoubtedly be made at the source. Methods to reduce engine noise during take-off and landing operations are under constant study. Modern jet engines are being made quieter. However, no major breakthrough is expected in the foreseeable future in terms of a substantial reduction in the general level of noise nuisance. For although aircraft may be relatively quiet in the future, the number of flights is likely to increase.

2. Main sources of noise

Near airports, two sources of aircraft noise must be considered:

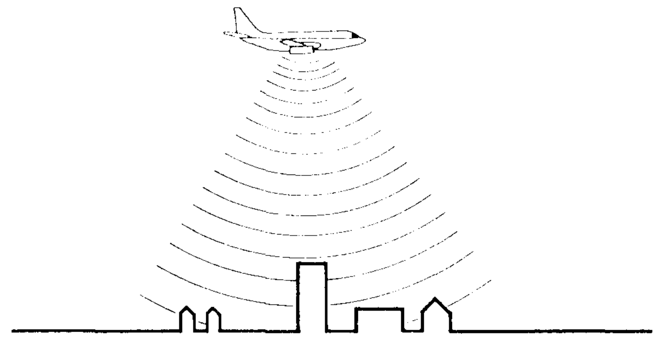


Figure 1.

a) Flyover: flyover noise which occurs under flight paths close to airports is the most serious and common problem source. As the aircraft passes, sound waves strike the house from a progression of different directions and distances. As a result, at any particular location the noise level rises to a peak and then decreases. The noise nuisance is most acute near the ends of runways.

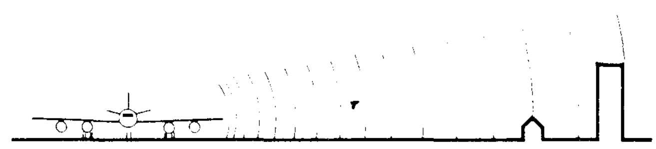


Figure 2.

b) Ground: the noise emitted by an aircraft during operations, i.e. engine runup, taxiing and take-off, is less variable in direction than with flyover noise but is usually of longer duration. The noise nuisance is most acute in positions close to the runway or in the vicinity of the ground runup position.

3. Evaluation of noise

As problems caused by aircraft noise have become more acute a number of methods have been devised for evaluating noise exposure in the vicinity of airports. These methods, international in origin, are similar. They all combine many factors into a single number evaluation. The system currently used by Transport Canada is the Noise Exposure Forecast (NEF).

4. Noise Exposure Forecast

The calculation of NEF requires information about the types of aircraft using the airport and the noise they generate, the number of take-offs and landings on each runway, and when these take-offs and landings occur. The noise generated by each individual aircraft type is measured in effective perceived noise decibels (EPNdB).

The EPNdB value takes into account the subjectively annoying effects of the noise, including pure tones and duration. A summation is made of the noise (in EPNdB) from all aircraft types on all runways in calculating NEF values. The NEF system is used primarily to develop noise contours for areas around airports, although it can be used to provide a noise exposure value for one particular location. Figure 3 illustrates an NEF contour map for a Canadian airport of medium size. It is important to note that NEF values increase in a logarithmic manner. Thus, an increase of 10 NEF units has the effect of making the noise seem twice as loud.

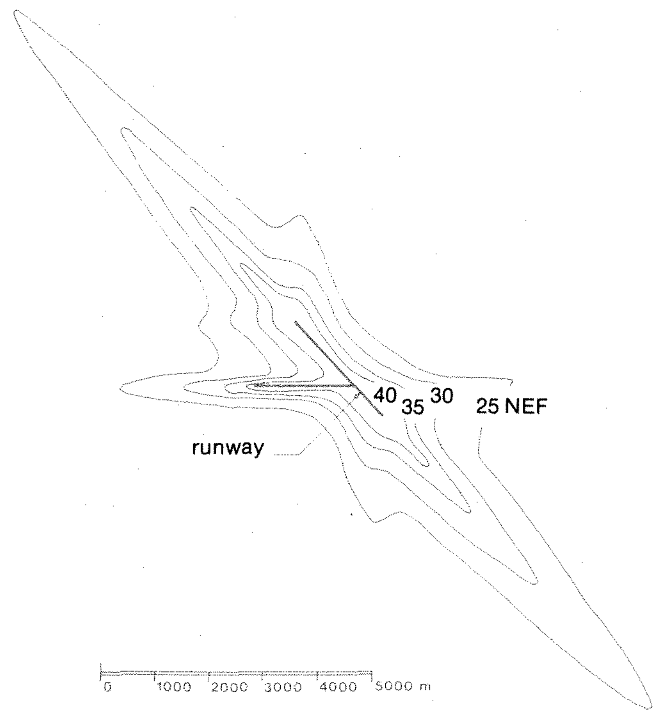


Figure 3. NEF contour map

5. NEF contours

Transport Canada and the Department of National Defence have provided Noise Exposure Forecast contours for major airports in Canada. These contours are based upon the most up-to-date information available and, where possible, on expected future conditions.

Section C
Classification of areas adjacent to airports

1. General
The National Research Council has analyzed many studies which have related human annoyance, complaint and speech interference to various noise ratings. Based on these studies the Council has related Noise Exposure Forecast values to an acceptable residential environment.

2. Community reaction
Sociological surveys (see Bibliography No. 22) have indicated that adverse community reaction may start at about 25 NEF. Above 30 NEF, complaints become increasingly vigorous and may be expected to take the form of concerted group action. Above 40 NEF, legal action may be expected.

The pattern of likely community reaction has been detailed by Transport Canada (see Bibliography No. 2) as follows:

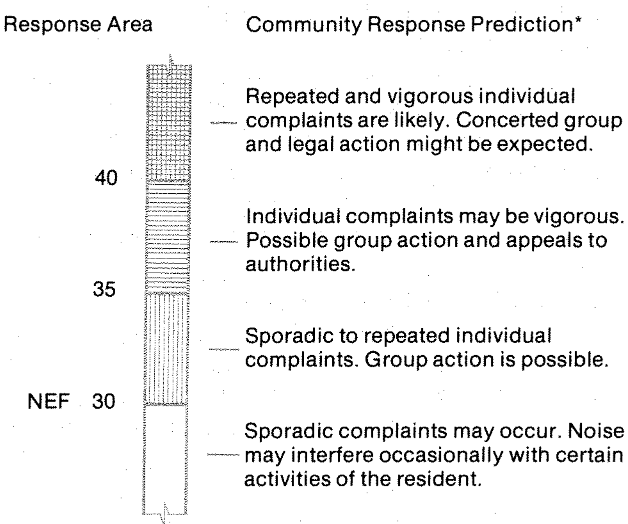


Figure 4.

3. NEF limits
Authorities must therefore expect complaints where outdoor NEF values exceed 25. Some people, however, are prepared to live where noise exposure is above this value, particularly if their dwelling provides an acceptable indoor noise environment. While it is theoretically possible to provide sufficient insulation to achieve an acceptable indoor noise environment in an area of very high outdoor noise, there is a level above which aircraft noise seriously affects living conditions no matter how much sound insulation has been applied to the actual dwelling unit.

Based particularly upon an analysis of available information with respect to scales of annoyance, complaint and the proposals and requirements of other authorities, the National Research Council considers that, with adequate sound insulation, residential development could be appropriate up to the 35 NEF level. Above this the annoyance caused by aircraft noise so seriously affects the environment that residential development should not be encouraged. This upper level will remain under constant review.

Normal construction in new residential buildings should provide an acceptable indoor noise environment up to the 25 NEF level. The evidence suggests that a broad threshold exists at the 25 NEF level above which there is an ever-increasing likelihood that normal construction will be unable to provide adequate insulation against aircraft noise. The National Research Council advises that the methods suggested in this publication for determining adequate sound insulation should be applied at the 25 NEF level and above. Transport Canada has advised the Corporation, however, that the accuracy of the NEF contours decreases with distance from the runway. While the 30 NEF contour is considered acceptable, the 25 NEF contour, because of deviations by aircraft from straight flight paths, cannot be accurately delineated. Consequently, although this contour is provided by Transport Canada and is indicated on published contour maps, it is only used to indicate in general terms where normal construction may no longer be able to provide adequate sound insulation against aircraft noise.

4. Identification of zones
The Corporation, by reference to the appropriate Transport Canada NEF contours, has identified the following zones adjacent to airports:

a) an upper zone — where NEF values are greater than 35.

b) an intermediate zone — where NEF values are between 30 and 35 inclusive.

c) a lower zone — where NEF values are between 25 and 30.

*It should be noted that the above community response predictions are generalizations based upon experience resulting from the evolutionary development of various noise exposure units used by other countries.

1. Where specific Noise Exposure Forecasts are available

For all airports for which Noise Exposure Forecast contours have been made available by Transport Canada or the Department of National Defence, the Corporation has prepared NEF contour maps and considers the following application appropriate:

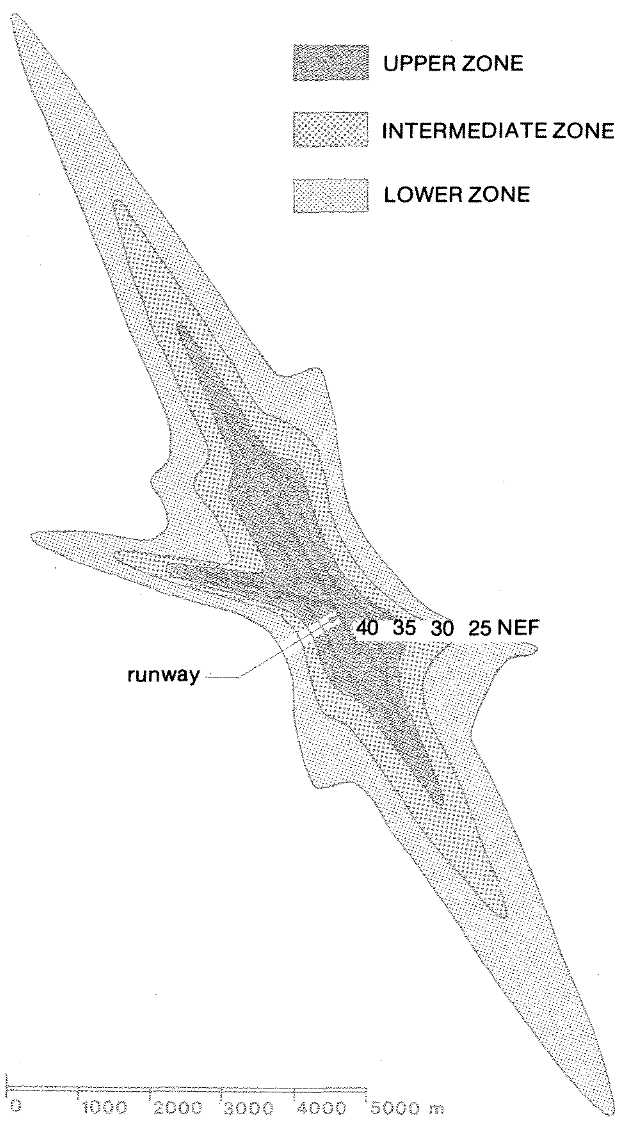


Figure 5. Noise zones where NEF contours are available

a) the upper zone is unsuitable for housing

b) the intermediate zone is unsuitable for housing unless adequate sound insulation is provided, and

c) in the lower zone, the provision of adequate sound insulation is recommended. The upper third of this zone is unsuitable for housing, i.e. between 28 and 30 NEF, when the sound insulation proposed is substantially below that considered to be adequate.

For specific airports, these maps may be obtained at the CMHC office in whose area the airport is located.

2. Where specific Noise Exposure Forecasts are not available

Specific forecasts are not available for all airports and the lack of aircraft movement data may prevent their preparation.

For CIVIL airports Transport Canada has prepared a series of general aviation contours. These contours are applied at such airports in accordance with the best advice available as coordinated by Transport Canada. The general aviation contours have the same technical base as the specific forecasts and should be used in the same way as the specific forecasts detailed in Section D.1.

For MILITARY airports the Department of National Defence considers the general aviation contours might underrate the noise generated by military operations. For these cases an appropriate alternative is related to the capability of the airport to handle jet aircraft and consequently is based on the length of the runway. Residential development should not be considered within an area related to the runway length as shown below:

Where runway length is 1500 metres or more

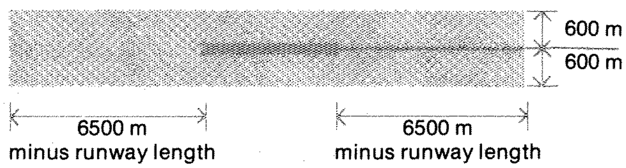


Figure 6a. Noise zone at military airports where NEF contours are not available.

a) an area extending from each end of the runway, a distance of 6500 m minus the length of the runway and laterally 600 m on each side of the centre line of the runway and its projection where the runway length is 1500 m or more.

Where runway length is less than 1500 metres

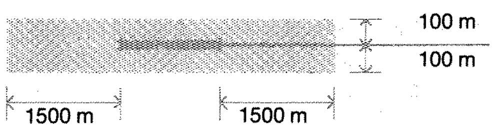


Figure 6b. Noise zone at military airports where NEF contours are not available.

b) an area extending 1500 m from each end of the runway and laterally 300 m on each side of the centre line of the runway and its projection where the runway length is less than 1500 m.

3. Other airports

New types of airports such as STOL ports are being studied. These tend to have different noise patterns and location characteristics from those of major airports. In residential development near such airports, consideration should be given to the individual circumstances applicable in each case.

4. Current status

As airport conditions change, NEF contour maps will be updated and maps may be provided for airports which now do not have them. There may also be improvements in methods of calculating and assessing noise exposure. Consequently, the Corporation will keep the above policy under constant review and will adapt and amend it as necessary.

Section E
Adequate sound insulation

1. General

Where noise exposure values are between 25 and 35 NEF inclusive, adequate sound insulation is recommended in new dwellings. To achieve this, the building envelope, consisting of the roof and the exterior walls, doors and windows (referred to as the building components), must be capable of reducing the outdoor noise to an acceptable indoor level. The National Research Council has developed the following method which, given the NEF for the location in question, determines the appropriate building components which will provide adequate sound insulation.

The appropriate building components for any room are selected on the basis of the Acoustic Insulation Factor (AIF). This factor, which takes account of several variables including the number of components forming the envelope of the room, provides the link between the NEF and those components which will give adequate sound insulation.

Transport Canada and the Department of National Defence provide contours at different intervals and the intermediate contours are not evenly spaced because of the logarithmic nature of the contour calculation. An appropriate method of accurately locating any of the missing contours is to determine the distance between, for example, the 25 and 30 NEF contours and if this is S, the 29 contour will be at 0.15S from the 30, the 28 at 0.33S, the 27 at 0.52S and the 26 at 0.74S. The contours between 30 and 35 can be located in the same way.

2. Method

The appropriate building components for any room in a dwelling are selected as follows:

a) determine by reference to the Corporation's NEF contour map for the airport concerned the NEF for the building location. If the location falls between two NEF values the higher value should be used.

b) determine whether the required AIF is for the components of a bedroom or other room.

c) determine the number of components which make up the exterior envelope of the room from windows, walls, ceiling-roofs and doors. It should be noted:

  (i) where the windows and exterior doors do not form part of the exterior envelope of a room (for example the front door and small adjacent window shown in Figure 12) they must be treated and included as a component of all rooms which have an opening or doorway opposite or adjacent to them.

  (ii) since the AIF is related to the total area of each type of component, the number of individual units of each type does not affect the determination of AIF. For example, 6 individual windows in a room are counted as one component and their total area is used in the calculation of AIF.

d) determine the Acoustic Insulation Factor from the following Tables:

Table 1: Required Acoustic Insulation Factor

	Bedrooms				Living/Dining/ Recreation				Kitchen/ Bathroom			
NEF	Number of Components Forming the Building Envelope											
	1	2	3	4	1	2	3	4	1	2	3	4
25	25	28	30	31	20	23	25	26	15	18	20	21
26	26	29	31	32	21	24	26	27	16	19	21	22
27	27	30	32	33	22	25	27	28	17	20	22	23
28	28	31	33	34	23	26	28	29	18	21	23	24
29	29	32	34	35	24	27	29	30	19	22	24	25
30	30	33	35	36	25	28	30	31	20	23	25	26
31	31	34	36	37	26	29	31	32	21	24	26	27
32	32	35	37	38	27	30	32	33	22	25	27	28
33	33	36	38	39	28	31	33	34	23	26	28	29
34	34	37	39	40	29	32	34	35	24	27	29	30
35	35	38	40	41	30	33	35	36	25	28	30	31

e) select the appropriate types of window, exterior wall, ceiling-roof and exterior door respectively from Tables A to D, using the AIF obtained. Where the calculated AIF does not correspond directly to an AIF value given in the table, the next higher AIF value should be used. All the appropriate components so indicated are the minimum required to provide the degree of sound insulation recommended.

   Table A — relates various types of window to AIF. Use of the table requires a calculation of the percentage of the total window area affecting a room to the total floor area of that room.

   Table B — relates various types of exterior wall construction to AIF. Use of the table requires a calculation of the percentage of total exterior wall area (less windows and doors) to total floor area.

   Table C — relates various ceiling-roof combinations to AIF.

   Table D — relates various types of exterior door to AIF. Use of the table requires a calculation of the percentage of the total door area affecting a room to the total floor area of that room.

   Table E — relates floor area to component area. Use of the table gives the percentages required in Tables A, B and D.

f) if a component is chosen whose AIF exceeds the required value by 10 or more, that component shall not be included in the number of elements when determining the AIF required for the other components of the room envelope.

Where a window or exterior door type has been determined in relation to more than one room, it shall comply with the highest insulation standard so calculated. The Tables A to D have been compiled by the National Research Council from laboratory tests on various components. They may be revised from time to time as methods and standards of construction change and as the results of a series of field tests become available and are evaluated.

3. Associated ventilation needs

The AIF values in the tables apply to closed, fully weatherstripped doors and windows. Because the noise insulation criteria cannot be met by conventional windows when they are opened to provide ventilation, alternative means of ventilation are necessary. (See Appendix C.)

4. Alternative procedures

Where a proponent wishes to give more detailed consideration to the problem of noise and the subject of sound insulation, he is advised to consult a person suitably qualified in acoustics.

Table A: Acoustic Insulation Factor for various types of window

Window area as a percentage of total floor area of room[1]															Double glazing of indicated glass thickness					Triple glazing	
4	5	6	8	10	13	16	20	25	32	40	50	63	80	Single glazing	2 mm and 2 mm glass	3 mm and 3 mm glass	4 mm and 4 mm glass	3 mm and 6 mm glass	6 mm and 6 mm glass	3 mm, 3 mm and 3 mm glass	3 mm, 3 mm and 6 mm glass
Acoustic Insulation Factor (AIF)[2]														Thickness	Interpane spacing (mm)[3]					Interpane spacing (mm)[5]	
35	34	33	32	31	30	29	28	27	26	25	24	23	22	2 mm	6						
36	35	34	33	32	31	30	29	28	27	26	25	24	23		13						
37	36	35	34	33	32	31	30	29	28	27	26	25	24	3 mm	15	6					
38	37	36	35	34	33	32	31	30	29	28	27	26	25	4 mm, 6 mm	18	13	6				
39	38	37	36	35	34	33	32	31	30	29	28	27	26		22	16	13	6	6	6,6	
40	39	38	37	36	35	34	33	32	31	30	29	28	27	9 mm[4]	28	20	16	13	13	6,10	6,6
41	40	39	38	37	36	35	34	33	32	31	30	29	28		35	25	20	16	16	6,15	6,10
42	41	40	39	38	37	36	35	34	33	32	31	30	29	12 mm[4]	42	32	25	20	20	6,20	6,15
43	42	41	40	39	38	37	36	35	34	33	32	31	30		50	40	32	25	24	6,30	6,20
44	43	42	41	40	39	38	37	36	35	34	33	32	31		63	50	40	32	30	6,40	6,30
45	44	43	42	41	40	39	38	37	36	35	34	33	32		80	63	50	40	37	6,50	6,40
46	45	44	43	42	41	40	39	38	37	36	35	34	33		100	80	63	55	50	6,65	6,50
47	46	45	44	43	42	41	40	39	38	37	36	35	34		125	100	80	75	70	6,80	6,65
48	47	46	45	44	43	42	41	40	39	38	37	36	35		150	125	100	95	90	6,100	6,80
49	48	47	46	45	44	43	42	41	40	39	38	37	36			150	125	110	100		6,100
50	49	48	47	46	45	44	43	42	41	40	39	38	37				150	135	125		

Source: National Research Council, Division of Building Research, June 1980.

Explanatory notes:

(1) Where the calculated percentage window area is not presented on a column heading, the nearest percentage column in the table values should be used.

(2) AIF data listed in the table are for well-fitted weatherstripped units that can be opened. The AIF values apply only when the windows are closed. For windows fixed and sealed to the frame, add three to the AIF given in the table.

(3) If the interpane spacing or glass thickness for a specific double-glazed window is not listed in the table, the nearest listed values should be used.

(4) The AIF ratings for 9 mm and 12 mm glass are for laminated glass only; for solid glass subtract two from the AIF values listed in the table.

(5) If the interpane spacings for a specific triple-glazed window are not listed in the table, use the listed case whose combined spacings are nearest the actual combined spacing.

(6) The AIF data listed in the table are for typical windows, but details of glass mounting, window seals, etc. may result in slightly different performance for some manufacturers' products. If laboratory sound transmission loss data (conforming to ASTM test method E-90) are available, these should be used to calculate the AIF.

(7) For easy reference, glazing dimensions are written in the form 2(100)2 to denote 2 mm glass (100 mm space) 2 mm glass.

Table B: Acoustic Insulation Factor for various types of exterior wall

Percentage of exterior wall area to total floor area of room	16	20	25	32	40	50	63	80	100	125	160	Type of Exterior Wall
	39	38	37	36	35	34	33	32	31	30	29	EW1
	41	40	39	38	37	36	35	34	33	32	31	EW2
	44	43	42	41	40	39	38	37	36	35	34	EW3
	47	46	45	44	43	42	41	40	39	38	37	EW4
Acoustic	48	47	46	45	44	43	42	41	40	39	38	EW1R
Insulation	49	48	47	46	45	44	43	42	41	40	39	EW2R
Factor	50	49	48	47	46	45	44	43	42	41	40	EW3R
	55	54	53	52	51	50	49	48	47	46	45	EW5
	56	55	54	53	52	51	50	49	48	47	46	EW4R
	58	57	56	55	54	53	52	51	50	49	48	EW6
	59	58	57	56	55	54	53	52	51	50	49	EW7 or EW5R
	63	62	61	60	59	58	57	56	55	54	53	EW8

Source: National Research Council, Division of Building Research, December 1980.

Explanatory notes:

1) Where the calculated percentage wall area is not presented as a column heading, the nearest percentage column in the table should be used.
2) The common structure of walls EW1 to EW5 is composed of 12.7 mm gypsum board, vapour barrier, and 38 × 89 mm studs with 50 mm (or thicker) mineral wool or glass fibre batts in the inter-stud cavities.
3) EW1 denotes exterior wall as in Note 2), plus sheathing, plus wood siding or metal siding and fibre backer board.
   EW2 denotes exterior wall as in Note 2), plus rigid insulation (25-50 mm), and wood siding or metal siding and fibre backer board.
   EW3 denotes simulated mansard with structure as in Note 2), plus sheathing, 38 × 89 mm framing, sheathing, and asphalt roofing material.
   EW4 denotes exterior wall as in Note 2), plus sheathing and 20 mm stucco.
   EW5 denotes exterior wall as in Note 2), plus sheathing, 25 mm air space, 100 mm brick veneer.
   EW6 denotes exterior wall composed of 12.7 mm gypsum board, rigid insulation (25-50 mm), 100 mm back-up block, 100 mm face brick.
   EW7 denotes exterior wall composed of 12.7 mm gypsum board, rigid insulation (25-50 mm), 140 mm back-up block, 100 mm face brick.
   EW8 denotes exterior wall composed of 12.7 mm gypsum board, rigid insulation (25-50 mm), 200 mm concrete.
4) R signifies the mounting of the interior gypsum board on resilient clips.
5) An exterior wall conforming to rainscreen design principles and composed of 12.7 mm gypsum board, 100 mm concrete block, rigid insulation (25-50 mm), 25 mm air space, and 100 mm brick veneer has the same AIF as EW6.
6) An exterior wall described in EW1 with the addition of rigid insulation (25-50 mm) between the sheathing and the external finish has the same AIF as EW2.

Table C: Acoustic Insulation Factor for various ceiling-roof combinations

Acoustic Insulation Factor	Type of Ceiling-Roof
41	C1
44	C1R or C1D
47	C2 or C1DR
49	C3
50	C2D
52	C2DR

Source: National Research Council, Division of Building Research, December 1980.
Explanatory notes:
1) C1 denotes 12.7 mm gypsum board, 75 mm (or thicker) insulation batts, flat roof joist and beam construction, built-up roofing.
   C2 denotes 12.7 mm gypsum board, 75 mm (or thicker) insulation batts, typical wood roof truss with ventilated attic, sheathing and asphalt roofing.
   C3 denotes paint finish, 150 mm concrete slab, 50 mm rigid insulation, built-up roofing.
2) D signifies the addition of a second layer of 12.7 mm gypsum board.
   R signifies mounting the gypsum board on wood strapping or resilient clips.
   DR signifies the addition of a second layer of 12.7 mm gypsum board mounted on resilient clips.
3) Wherever possible ventilation openings to attic spaces should be in locations not directly exposed to the noise.

Table D: Acoustic Insulation Factor for various types of exterior doors

Percentage of total door area to total floor area of room	4	5	6.3	8	10	12.5	16	20	25	Exterior Type of Exterior Door
	30	29	28	27	26	25	24	23	22	D1
	34	33	32	31	30	29	28	27	26	D2
	36	35	34	33	32	31	30	29	28	D3
	37	36	35	34	33	32	31	30	29	D4
Acoustic	38	37	36	35	34	33	32	31	30	D5 or D1 — sd
Insulation	41	40	39	38	37	36	35	34	33	D2 — sd
Factor	43	42	41	40	39	38	37	36	35	D3 — sd
	44	43	42	41	40	39	38	37	36	D4 — sd
	45	44	43	42	41	40	39	38	37	D5 — sd
	48	47	46	45	44	43	42	41	40	D3 — D3
	50	49	48	47	46	45	44	43	42	D5 — D5

Source: National Research Council, Division of Building Research, December 1980.
Explanatory notes:
1) Where the calculated percentage door area is not presented as a column heading, the nearest percentage column in the table should be used.
2) All prime doors must be fully weatherstripped.
3) D1 denotes 44 mm hollow-core wood door (up to 20% of area glazed).
   D2 denotes 44 mm glass-fibre reinforced plastic door with foam or glass-fibre insulated core (up to 20% of area glazed).
   D3 denotes 35 mm in solid slab wood door.
   D4 denotes 44 mm steel door with foam or glass-fibre insulated core.
   D5 denotes 44 mm solid slab door.
4) sd denotes storm door of wood or aluminum with openable glazed sections. The AIF values apply when the glazed sections are closed.
5) Except as noted specifically above, doors shall not have inset glazing.

Table E: Component area percentage relative to total floor area of a room (areas in square metres)

Total area of windows, or doors or exterior walls in square metres	Total floor area of room in square metres														
	2.7 to 3.2	3.3 to 4.1	4.2 to 5.2	5.3 to 6.6	6.7 to 8.3	8.4 to 10.4	10.5 to 13.0	13.1 to 16.6	16.7 to 20.8	20.9 to 26.0	26.1 to 33.1	33.2 to 41.3	41.4 to 52.1	52.2 to 65.7	65.8 to 88.3
0.42 to 0.52	16	12.5	10	8	6.3	5	4								
0.53 to 0.66	20	16	12.5	10	8	6.3	5	4							
0.67 to 0.83	25	20	16	12.5	10	8	6.3	5	4						
0.84 to 1.04	32	25	20	16	12.5	10	8	6.3	5	4					
1.05 to 1.30	40	32	25	20	16	12.5	10	8	6.3	5	4				
1.31 to 1.67	50	40	32	25	20	16	12.5	10	8	6.3	5	4			
1.68 to 2.04	63	50	40	32	25	20	16	12.5	10	8	6.3	5	4		
2.1 to 2.6	80	63	50	40	32	25	20	16	12.5	10	8	6.3	5	4	
2.7 to 3.2	100	80	63	50	40	32	25	20	16	12.5	10	8	6.3	5	4
3.3 to 4.1	125	100	80	63	50	40	32	25	20	16	12.5	10	8	6.3	5
4.2 to 5.2	160	125	100	80	63	50	40	32	25	20	16	12.5	10	8	6.3
5.3 to 6.6		160	125	100	80	63	50	40	32	25	20	16	12.5	10	8
6.7 to 8.3			160	125	100	80	63	50	40	32	25	20	16	12.5	10
8.4 to 10.4				160	125	100	80	63	50	40	32	25	20	16	12.5
10.5 to 13.0					160	125	100	80	63	50	40	32	25	20	16
13.1 to 16.6						160	125	100	80	63	50	40	32	25	20
16.7 to 20.8							160	125	100	80	63	50	40	32	25
20.9 to 26.0								160	125	100	80	63	50	40	32
26.1 to 33.1									160	125	100	80	63	50	40
33.2 to 41.3										160	125	100	80	63	50
41.4 to 51.2											160	125	100	80	63

1. General

This document has referred to the fact that sound usually enters a room by more than one route; that for upstairs rooms the paths are via windows, exterior walls and ceiling-roofs; that for downstairs, the primary agents of transmission are windows, exterior walls and exterior doors, and that principal consideration should be given to the following as contributing to insulation from externally generated sound:

a) the reduction of window areas to the minimum required for adequate lighting;

b) the provision of mechanical means of ventilation to reduce the need to open windows for ventilation purposes;

c) the use of building materials with high insulation qualities. Heavy materials are usually more effective in countering sound transmission;

d) the sealing of all cracks and joints between building components. Where possible, the connections between building components should incorporate resilient fastenings. Glass should be set in resilient gaskets;

e) the incorporation of special design features where breaks occur in the exterior envelope. For example, sound baffles may be necessary in locations such as crawl space and ventilation grilles, plumbing vents, air-conditioning grilles, exhaust vents for kitchens and bathrooms, fresh-air intake grilles and chimney flues.

2. Additional considerations

The following considerations provide advice which may be useful to those concerned with providing residential accommodation sited near airports. They might be used, with advantage, where a particular room or building requires greater noise protection than normally expected. Reduction of noise nuisance may be achieved by the introduction of acoustic considerations into site layout and into other aspects of dwelling design.

a) External Shielding — the effects of noise generated from aircraft while on the runway may be reduced by introducing between the dwelling and the noise source:

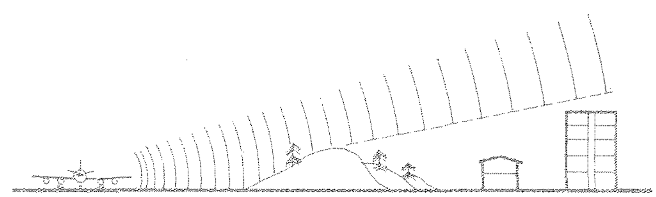


Figure 7. Shielding from ground noise

(i) mounds, walls or parts of buildings not sensitive to excessive sound, and/or

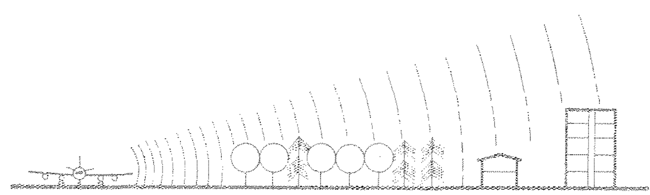


Figure 8. Absorption of ground noise

(ii) vegetation in sufficient amounts; for example, a large tract of trees around an airport, and by

(iii) careful orientation and landscaping of building groups to avoid the reflection of sound waves from facade to facade.

b) Building Layout and Orientation — within a dwelling it is possible to reduce noise levels in those rooms where noise can least be tolerated (e.g. bedrooms) by shielding them with other rooms where higher noise levels are acceptable.

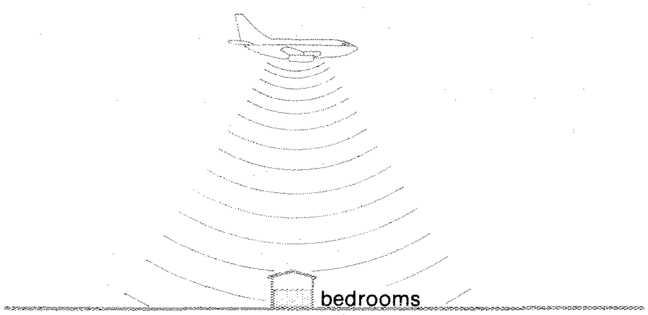


Figure 9.

Thus, where flyover noise is the problem, bedrooms could, with advantage, be located below other rooms.

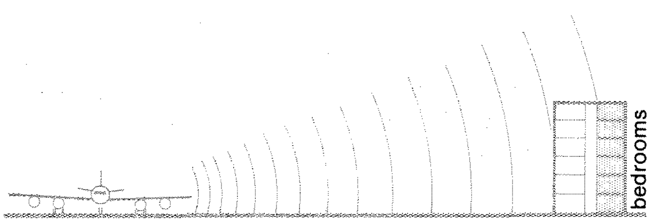


Figure 10.

Where ground noise is the problem, bedrooms could be located on the side of the dwelling furthest from the noise source.

c) Interior Decoration — the noise level in the interior of a dwelling can be reduced by the use of materials with sound-absorbent surfaces, such as acoustic ceilings, heavy curtain fabrics and floor carpeting. Interior doors should be kept closed and automatic closers installed.

Appendix A
Calculating Acoustic Insulation Factor from laboratory data

One major problem associated with the use of AIF ratings is the need to rate components such as doors or windows produced by various manufacturers. Tables A, B, C, and D list AIF ratings for a broad range of components, but obviously do not include all possible constructions. Also, some manufacturers' windows or doors may provide more acoustical insulation than "typical" components because of special design features such as unusually good weatherstripping.

If such products have been tested in a laboratory in accordance with ASTM method E90 for Measurement of Sound Transmission Loss, the test results can be used to calculate the AIF. A detailed procedure for calculating the AIF and method for estimating the AIF from a laboratory Sound Transmission Class (STC) are presented below.

Detailed Calculation Procedure

The difference between the outdoor Noise Exposure Forecast (NEF) and the resulting indoor NEF depends on both the transmission loss characteristic of the component and the spectral content of the noise source.

The source spectrum used for AIF calculations is given in Table A1; it is normalized to approximately 80 dBA to provide a convenient range of values for the calculation. By subtracting the Sound Transmission Loss values from the A-weighted source sound levels, the corresponding A-weighted indoor sound levels in each ⅓-octave band are obtained. Combining these ⅓-octave band levels yields the overall A-weighted sound level that would be measured in a room if only that component were transmitting sound, and the component area were equal to the acoustical absorption (typically 80 per cent of room floor area). This level is subtracted from 77 dBA (a value obtained by combining the ⅓-octave band source levels and correcting to allow for differences between the source sound field at an exterior facade and that in laboratory test chambers, as discussed in the reference). This gives the AIF for component area equal to 80 per cent of room floor area. For other percentages (P) of component area relative to floor area, the AIF may be calculated by subtracting 10 log (P/80) from the AIF value for 80 per cent. The calculated values should be rounded to the nearest integer.

The calculation procedure is illustrated by the example given in the worksheet in Fig. A1.

Estimating the Acoustic Insulation Factor from STC

In some cases a manufacturer or his agent may know the STC of a product, but be unable to provide the ⅓-octave band Sound Transmission Loss data. This should not occur, because in order to determine the STC, one must first obtain the Sound Transmission Loss data for the ⅓-octaves from 125 Hz to 4000 Hz. Laboratory reports of STC determinations consistent with the ASTM standard E413 should include this information.

If detailed sound transmission loss data are not available, the AIF can be estimated from the STC value, using Table A2 for doors and windows, or Table A3 for walls. Because the estimate tends to give slightly lower values for the AIF than are obtained from the detailed calculation, it is usually to a manufacturer's advantage to use the detailed calculation procedure.

Reference: *Acoustic Insulation Factor: A Rating for the Insulation of Buildings Against Outdoor Noise*, National Research Council, Division of Building Research. Building Research Note 148. Revised July 1980.

Table A1: Standard source spectrum for calculating Acoustic Insulation Factor (AIF)

Frequency (Hz)	Source Sound Pressure Level	A-weighted Source Sound Pressure Level
100	66.1	47
125	69.1	53
160	71.4	58
200	71.9	61
250	71.6	63
315	71.6	65
400	71.8	67
500	71.2	68
630	70.9	69
800	70.8	70
1000	70.0	70
1250	69.4	70
1600	69.0	70
2000	68.8	70
2500	68.7	70
3150	67.8	69
4000	67.0	68
5000	65.5	66

Note: Values in the second and third columns of this table are ⅓-octave band sound pressure levels expressed in dB.

Table A2: Approximate conversion from STC to AIF for windows and doors

Window (or door) Area Expressed as Percentage of Room Floor Area	Acoustic Insulation Factor (AIF)
80.0	STC-5
63.0	STC-4
50.0	STC-3
40.0	STC-2
32.0	STC-1
25.0	STC
20.0	STC+1
16.0	STC+2
12.5	STC+3
10.0	STC+4
8.0	STC+5
6.3	STC+6
5.0	STC+7
4.0	STC+8

Note: For area percentages not listed in the table, use the nearest listed value.

Examples: For a window whose area = 20% of the room floor area and STC = 32, the AIF is 32 + 1 = 33.
For a window whose area = 60% of the room floor area and STC = 29, the AIF is 29 - 4 = 25.

Table A3: Approximate conversion from STC to AIF for exterior walls and ceiling-roof systems.

Exterior Wall Area Expressed as Percentage of Room Floor Area	Acoustic Insulation Factor (AIF)
200.0	STC-10
160.0	STC-9
125.0	STC-8
100.0	STC-7
80.0	STC-6
63.0	STC-5
50.0	STC-4
40.0	STC-3
32.0	STC-2
25.0	STC-1
20.0	STC
16.0	STC+1
12.5	STC+2
10.0	STC+3
8.0	STC+4

Note: For area percentages not listed in the table, use the nearest listed value.

Example: For a wall whose area = 120% of room floor area and STC = 48, the AIF is 48 - 8 = 40.

Note: For ceiling-roof systems, AIF = STC - 7.

Figure A1: Worksheet for Calculating AIF from Transmission Loss Data

Frequency (Hz)	A-weighted Source Sound Pressure Level (dB)	Sound Transmission Loss (dB)	A-weighted Indoor Sound Pressure Level (dB)	Energy Equivalent of Indoor SPL
	(A)	(B)	(C = A-B)	($D = 10^{c/10}$)
100	47	24	23	200
125	53	26	27	501
160	58	19	39	7 943
200	61	21	40	10 000
250	63	20	43	19 953
315	65	20	45	31 623
400	67	25	42	15 849
500	68	30	38	6 310
630	69	33	36	3 981
800	70	37	33	1 995
1000	70	39	31	1 259
1250	70	41	29	794
1600	70	43	27	501
2000	70	44	26	398
2500	70	45	25	316
3150	69	43	26	398
4000	68	37	31	1 259
5000	66	35	31	1 259
		Sum of values in column D:		104 539=E

Calculated indoor A-weighted sound level: $10 \log_{10}$ (E) = 50.2 = F

AIF (component area = 80% of floor area): (77 - F) = 26.8 = G

Component Area as a Percentage of Room Floor Area	Acoustic Insulation Factor (AIF)
6.3	(G + 11) = 38
8.0	(G + 10) = 37
10.0	(G + 9) = 36
12.5	(G + 8) = 35
16.0	(G + 7) = 34
20.0	(G + 6) = 33
25.0	(G + 5) = 32
32.0	(G + 4) = 31
40.0	(G + 3) = 30
50.0	(G + 2) = 29
63.0	(G + 1) = 28
80.0	(G) = 27
100.0	(G - 1) = 26
125.0	(G - 2) = 25
160.0	(G - 3) = 24

Appendix B
Derivation of Table 1

The Acoustic Insulation Factors set out in Table 1 are obtained by the following steps:

1. Take the numerical value of the NEF contour for the location under consideration.
2. To derive the sound insulation requirement for the exterior building envelope of a particular room, adjust the outdoor NEF value as follows:

   For bedrooms add 0
   For living/dining/recreation rooms deduct 5
   For kitchen/bathrooms and other rooms deduct 10

   These values of NEF + 0, NEF - 5 and NEF - 10 for the sound insulation required in the building envelope have been recommended by the National Research Council based particularly on a review of studies related to thresholds of annoyance and speech interference. They are related to acceptable indoor noise levels equivalent to NEF = 0 units for bedrooms, NEF = + 5 for living, dining and recreation rooms and NEF = + 10 for kitchens, bathrooms and other rooms. The difference of 5 units between each of the different types of accommodation allows for the desirability of reducing the noise level relative to the particular use and of having the least noise in sleeping accommodation.
3. To arrive at the sound insulation required for the individual components of the room envelope: make no adjustment to the above figures when there is 1 component, add 3 where there are 2 components, add 5 where there are 3 components, and add 6 where there are 4 components.

   These adjustments are made because, as more components are added to the exterior room envelope, the effective insulation of all components is reduced.

   The final figure is the Acoustic Insulation Factor.

To summarize:

Number of components forming the Room Envelope	AIF for		
	Bedrooms	Living/Dining/ Recreation	Kitchens/ Bathrooms
1 component	NEF	NEF - 5 = -5	NEF - 10 = -10
2 components	NEF + 3	NEF - 5 + 3 = -2	NEF - 10 + 3 = - 7
3 components	NEF + 5	NEF - 5 + 5 = 0	NEF - 10 + 5 = - 5
4 components	NEF + 6	NEF - 5 + 6 = +1	NEF - 10 + 6 = - 4

Associated ventilation needs

No matter what components are selected, the difference between the outdoor and indoor NEF is unlikely to exceed 20 dB if the windows are opened to provide ventilation. For residential rooms with a window opening of 0.3 m^2 (the minimum requirement of the Canadian Residential Standards), the noise reduction is typically between 10 and 20 dB, depending on the size and furnishing of the room. Obviously the noise reduction can be increased by partially closing the windows, but for sites where the NEF is greater than 25, the indoor noise limits of Table C.1 cannot be satisfied if the windows are opened appreciably. Although this does not pose a problem during the winter, the windows can only be kept closed during the summer if an alternative means of ventilation is provided. For most heavily populated areas in Canada a mechanical ventilation system would have to include air conditioning to provide reasonable comfort in the warmer months.

Insulating residential buildings against aircraft noise necessitates "alternative means of ventilation" for sites where the NEF is greater than or equal to 30. For sites where the NEF is between 25 and 30, an alternative means of ventilation is recommended, but not mandatory. In practice the phrase "alternative means of ventilation" is normally interpreted as a requirement for air conditioning.

Where it is not essential, developers may not wish to include air conditioning because of the resulting increase in the selling price or rental rate. The use of a forced-air heating system with ducting appropriate for air conditioning should be encouraged in such cases. This will permit the eventual occupants to readily add air conditioning at a later date if they find the noise admitted by opening the windows for ventilation to be unacceptable. Even without air conditioning, such a system can partially fulfil the ventilation requirements if provisions are made to exhaust the cold air return ducts to outside and suck fresh air from outside into the cold air return plenum. To minimize noise entering through the air-handling system, the inlet and outlet ducts should be designed to provide some noise attenuation. Lining the ducts with **suitable** acoustical absorption material and including at least one 90° bend in the lined segments is one example of such treatment.

Table C.1: Recommended Indoor Noise Exposure Criteria

Use of Space	Recommended Maximum Indoor NEF
Bedrooms	0
Living, Dining, Recreation	5
Kitchen, Bathroom	10

Reference: National Research Council, Division Building Research. Building Research Note 148 (Revised June 1980).

Minimum System for Mechanical Ventilation for Forced Warm Air, Fuel-Fired Systems

The following system may be considered to be the minimum acceptable to provide mechanical ventilation.

Components

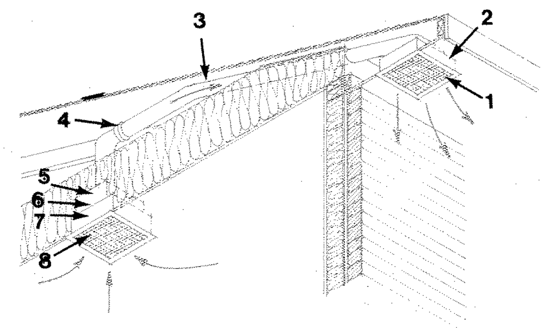
This system will comprise:

1. A fresh air inlet connecting the exterior to the cold air return plenum. (Minimum 150 mm diameter duct properly insulated, with regulating damper.)
2. A roof-ceiling exhaust fan or suitable alternative installation complete with damper and noise baffles. (Capacity for ¾ air change per hour.) It is recommended that the exhaust be located on the side of the house which is least exposed to sound.
3. A furnace with a two-speed circulating fan.
4. A manual damper located between the fresh air inlet and any cold air inlet in the main cold air return duct.

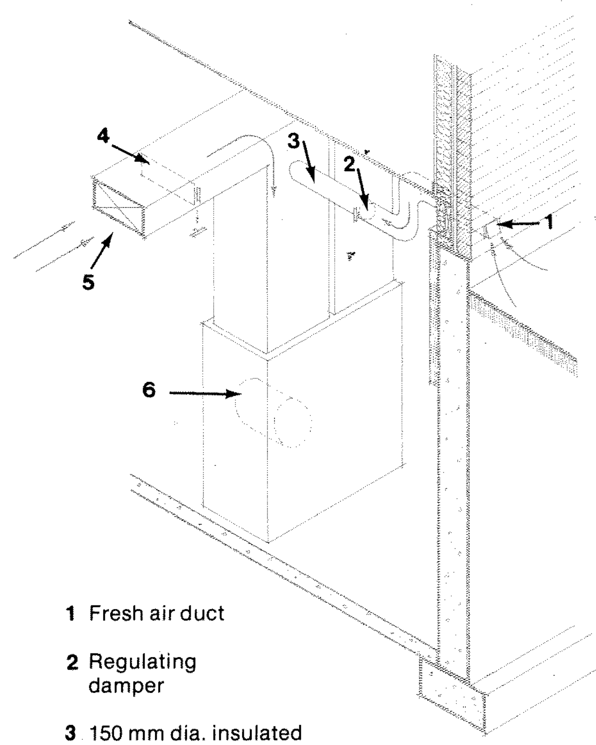
Operation

Winter — Fresh air will be drawn in through fresh air inlet to make up air lost through the chimney flue and the exhaust fan. This air is heated and distributed by the heating system. The damper on the cold air return is open. The two-speed fan on the furnace will ensure continuous operation. This should provide 1 air change per hour.

Summer — The damper on the cold air return is closed. The furnace fan will draw air through the fresh air inlet and circulate through the heating system. Stale air will escape through the chimney flue and the exhaust fan. For a standard furnace with a circulating fan, this should provide approximately five air changes per hour. It is recognized that for severe summer conditions this may not be sufficient and temporary additional ventilation by means of open windows may be necessary.



1 Exhaust vent
2 Sound alteration box
3 Insulated duct laid to slight fall to exterior
4 Flexible connection
5 Exhaust fan
6 Gasket
7 Silencer
8 Ceiling grille



1 Fresh air duct
2 Regulating damper
3 150 mm dia. insulated duct
4 Manual damper Summer - almost closed Winter - open
5 Cold air return
6 Circulating fan driven by 2-speed motor

Figure 11. Mechanical ventilation

Appendix D

Adjustments to the basic calculation of required AIF

It is recognized that other architectural considerations may lead to designs having some components with AIF ratings that exceed the requirements in Table 1. In such cases it is reasonable to slightly relax the AIF requirements for the other components of the building envelope. Where the AIF of any component exceeds the required AIF by 10 or more, the calculation should be repeated for the other components with the "total number of components" reduced by one. This reduction in the number of components lowers the required AIF for the others. No adjustment is made if a component's AIF exceeds the requirement by less than 10.

The most important design consideration is to ensure that the total noise reduction by the components is consistent with the desired difference between the outdoor and indoor noise exposures. The required AIF values in Table 1 indicate the average acoustical insulation required for the number of components in the exterior envelope of the room. Deviations from this average AIF are acceptable, provided the decrease in noise reduction by the weaker components is offset by a corresponding increase in noise reduction by the others. The necessary adjustments can be calculated by simply using Table D.1, as illustrated in the following example. (Note that the "average" AIF is **not** a simple arithmetic average of the component AIF values.)

Example

Consider the design for a bedroom in a house at a site where the NEF = 32. The room has three components in its exterior envelope: ceiling-roof, exterior wall and windows. From Table 1 the average required AIF is 37. If other architectural considerations led to choosing a ceiling-roof with an AIF = 50 and an exterior wall with an AIF = 43, what AIF is required for the windows?

Using Table D1, the ceiling-roof, with an AIF more than 10 points above the required average value, is rated at - 30 in the three component column, i.e., it would transmit 30 per cent less than its share of the total transmitted sound. Similarly the selected wall, which has an AIF six points above the required average value, transmits 25 per cent less than its share. The total sound transmission by these two components is thus 55 per cent less than their share. Therefore the window component may be allowed to transmit up to 55 per cent more than its share of the total, and from Table D1 its AIF rating can be 4 below the specified average value, i.e. 37 - 4 = 33.

If the same situation was evaluated using the procedure established in Section E, the windows would be required to have AIF = 35 (the value from Table 1 for a bedroom with two components; the ceiling-roof is not included).

Table D1: Adjustment to AIF

Component AIF minus Average Required AIF	Total No. of Components 2	3	4	
10 or more	-45	-30	-22	
9	-44	-29	-22	
8	-42	-28	-21	
7	-40	-27	-20	
6	-37	-25	-19	
5	-34	-23	-17	Percentage
4	-30	-20	-15	change in
3	-25	-17	-12	total trans-
2	-18	-12	- 9	mitted sound
1	-10	- 7	- 5	
0	0	0	0	
-1	13	9	6	
-2	29	20	15	
-3	50	33	25	
-4	76	50	38	
-5	108	72	54	

Worksheet for Table D1: (Using Example)

Outdoor Noise Exposure Forecast . . 32
Number of Components .... 3 Average required AIF 37
Type of Room .... Bedroom (from Table 1)

Component	AIF	AIF Minus Average Required AIF	Increase in Transmitted Sound
Ceiling-Roof	50	13 (more than 10)	-30 %
Exterior Wall	43	6	-25 %
Windows	33	-4	50 %
Doors	—	—	— %

Overall increase in total transmitted sound = - 5 %
(sum of column above)

Reference: National Research Council
Division of Building Research
Building Research Note 148
(Revised June 1980).

Appendix E
Examples

Worked examples are given to illustrate the method of determining the building components for adequate sound insulation of dwellings. The examples are of a bungalow, a two-storey house, a row house and an apartment all located at the 35 NEF level. The examples are given for guidance purposes only and the opportunity is taken to highlight features which require careful consideration in making the calculation.

It will be noted that there are various alternatives open to builders and architects which will fulfil the sound insulation requirements. Alternatives have not been given in the examples which follow. Designing rooms to reduce the number of components in the envelope and the ratio of window area to floor area may permit the use of components with lighter materials. Careful design may avoid potential cost increases and facilitate standardization of components. However, it should be noted that components with higher Acoustic Insulation Factors are not necessarily more costly.

In practice many of the components used in typical apartment construction have to take account of the need for greater fire protection, thermal insulation, wind resistance, etc., and as a result they may be found to have adequate acoustic insulation from aircraft noise.

Example 1 A 3-bedroom bungalow

To determine the appropriate building components for this dwelling it is necessary to undertake calculations for the dining room, the living room, the kitchen, the three bedrooms, the bathroom and the basement. Two features of the dwelling require special consideration, the living room and dining room form one large room and the rear exterior door is adjacent to the doorways of both the kitchen and the dining room.

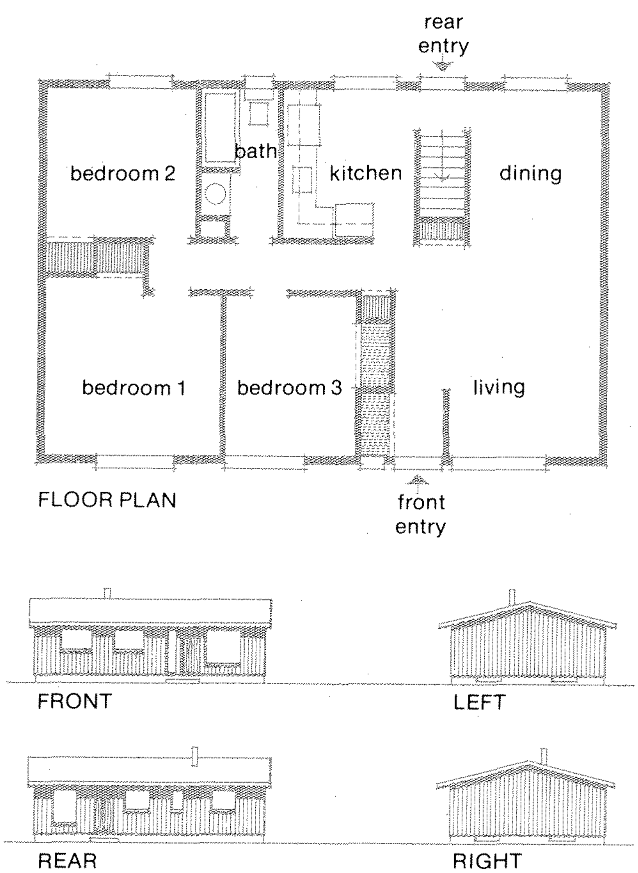


Figure 12. A 3-bedroom bungalow

Building location

35 NEF

Acoustic Insulation Factors

Dining-living room

The calculation is made for the entire area as one room. The components are:
First component: windows, including the window in the front closet.
Second component: exterior walls, measured from the back of the front closet to the rear door.
Third component: the ceiling-roof.
Fourth component: the front and rear exterior doors.
Total number of components = 4.
From Table 1: AIF = 36.

Kitchen

Components are the window, exterior wall, ceiling-roof and rear exterior door.
Total number of components = 4.
From Table 1: AIF = 31.

Bedrooms 1, 2 and 3

Each bedroom has three components — window, exterior wall and ceiling-roof.
From Table 1: AIF = 40.

Bathroom

Three components — window, exterior wall and ceiling-roof.
From Table 1: AIF = 30.

Basement

Two components — window and exterior wall.
From Table 1: AIF = 28.

Appropriate components

It is necessary at this stage to calculate the percentages of the total window area, total exterior door area and the net exposed exterior wall area. (i.e. excluding window and door areas) to the total floor area for each room. These percentages are:

Room	% Window area to total floor area	% Exterior wall area to total floor area	% Exterior door area to total floor area
Dining-living	26 (1)	110	14 (2)
Kitchen	16	72	26 (3)
Bedroom 1	15	134	—
Bedroom 2	13	155	—
Bedroom 3	22	57	—
Bathroom	20	77	—
Basement	4	27	—

Notes: (1) The window area includes the window in the front closet.
(2) The total door area is the area of the front and rear exterior doors.
(3) The total door area is the area of the rear exterior door only.

By reference to Tables A to D determine the appropriate components.

Summary

Dwelling: A 3-bedroom bungalow

Building location: NEF 35

Room	Dining-living	Kitchen	Bed-room 1	Bed-room 2	Bed-room 3	Bath-room	Base-ment
No. of components	4	4	3	3	3	3	2
Acoustic Insulation Factor (Table 1)	36	31	40	40	40	30	28
% Window to floor area	26	16	15	13	22	20	4
% Exterior wall to floor area	110	72	134	155	57	77	27
% Exterior door to floor area	14	26	—	—	—	—	—
			Appropriate components				
Windows (Table A)	2(63)2	3 mm	2(100)2	2(80)2	2(125)2	3 mm	2 mm
Exterior walls (Table B)	EW3	EW1	EW2R	EW3R	EW4	EW1	EW1
Ceiling-roof (Table C)	C1	C1	C1	C1	C1	C1	—
Exterior doors (Table D)	D2sd	D2sd	—	—	—	—	—

Example 2 A 4-bedroom two-storey detached house

To determine the appropriate building component for this dwelling it is necessary to undertake calculations for the dining room, the living room, the kitchen, the four bedrooms, the bathroom and the basement. Two features of the dwelling require special consideration: the living area and the dining area form one room and the dining room has a glazed and not a solid exterior door.

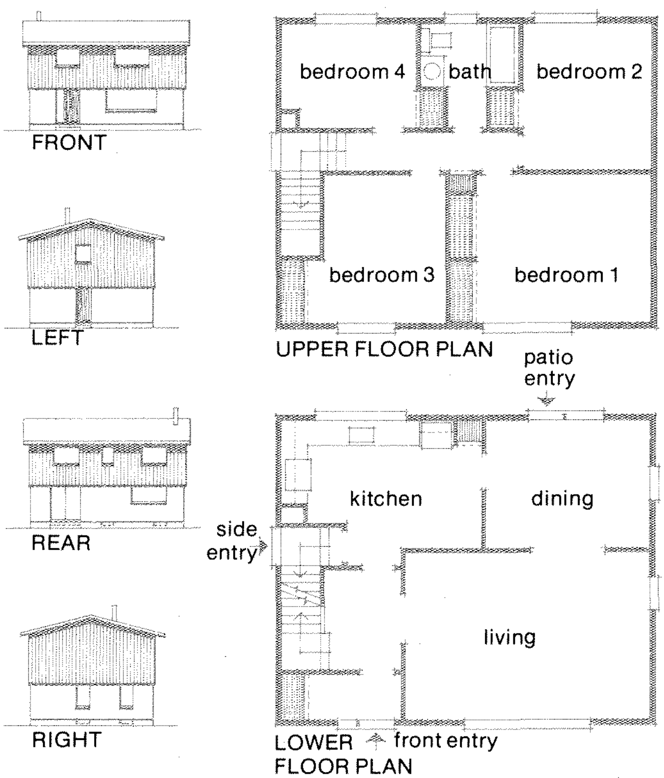


Figure 13. A 4-bedroom two-storey detached house

Building location

35 NEF

Acoustic Insulation Factors

Dining-living room

Because the exterior door in the dining room is fully glazed it is treated as a window and is included in the calculation of the percentage window area to floor area. A component is included for the front exterior door.

There are three components — window, exterior wall and exterior door.
From Table 1: AIF = 35.

Kitchen

The components are the window, exterior wall and exterior door (the latter consisting of both the front and side exterior doors). The total number of components = 3.
From Table 1: AIF = 30.

Bedrooms 1, 2, 3 and 4

Each bedroom has three components — window, exterior wall and ceiling-roof.
From Table 1: AIF = 40.

Bathroom

There are three components — window, exterior wall and ceiling-roof.
From Table 1: AIF = 30.

Basement

There are two components — window and exterior wall.
From Table 1: AIF = 28.

Appropriate components

It is necessary at this stage to calculate the percentages of the total window area, total exterior door area and the net exposed exterior wall area (i.e. excluding window and door areas) to the total floor area for each room. These percentages are:

Room	% Window area to total floor area	% Exterior wall area to total floor area	% Exterior door area to total floor area
Dining-living	29 (1)	89	8 (5)
Kitchen	22 (2)	100	23 (6)
Bedroom 1	20	100	—
Bedroom 2	22 (3)	117	—
Bedroom 3	21 (3)	100 (4)	—
Bedroom 4	31 (3)	114	—
Bathroom	22	87	—
Basement	4	20	—

Notes: (1) The window area includes the fully glazed dining room exterior door and the small window adjacent to the front exterior door.
(2) The window area includes the small window adjacent to front exterior door.
(3) The window area includes the stairwell window.
(4) The total exterior wall area includes the area of the side wall as far as the stairwell.
(5) The door area is that of the front exterior door only.
(6) The door area is that of the front and side exterior doors.

By reference to Tables A to D determine the appropriate components.

Summary

Dwelling: A 4-bedroom two-storey detached house
Building location: 35 NEF

Room	Dining-living	Kitchen	Bed-room 1	Bed-room 2	Bed-room 3	Bed-room 4	Bath-room	Base-ment
Number of components	3	3	3	3	3	3	3	2
Acoustic Insulation Factor (Table 1)	35	30	40	40	40	40	30	28
% Window to floor area	29	22	20	22	21	31	22	4
% Exterior wall to floor area	89	100	100	117	104	114	87	20
% Exterior door to floor area	8	23	—	—	—	—	—	—
			Appropriate components					
Windows (Table A)	3(50)3	3(6)3	3(100)3	3(100)3	3(100)3	3(150)3	3(6)3	2 mm
Exterior walls (Table B)	EW3	EW1	EW1R	EW2R	EW1R	EW2R	EW1	EW1
Ceiling-roof (Table C)	—	—	C1	C1	C1	C1	C1	—
Exterior doors (Table D)	D1sd	D1sd	—	—	—	—	—	—

Example 3 A 3-bedroom row house

To determine the appropriate building components for this dwelling it is necessary to undertake calculations for the kitchen-dining room, the living room, the bathroom and the three bedrooms. No calculation is required for the crawl space. The front and rear exterior doors open to a hallway; each is related for calculation purposes to the adjacent room.

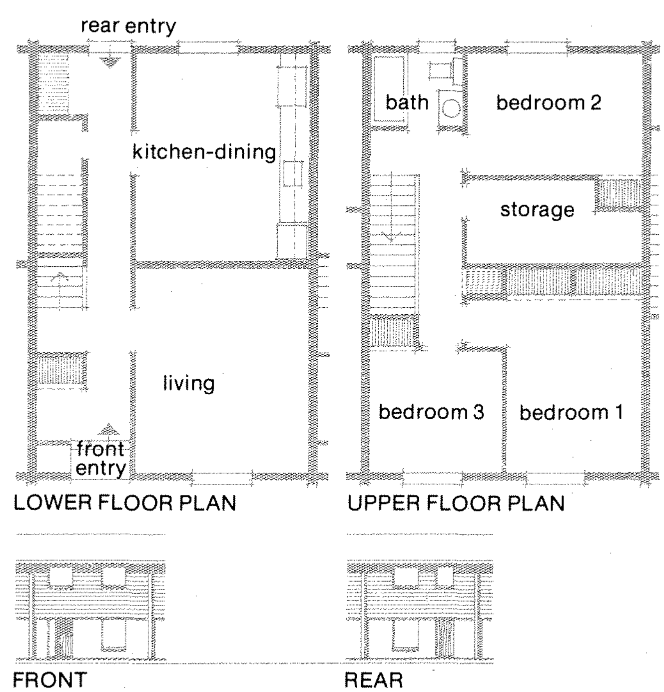


Figure 14. A 3-bedroom row house

Building location

35 NEF

Acoustic Insulation Factors

Living room

There are three components to this room — window, exterior wall and front exterior door.

From Table 1: AIF = 35.

Dining-kitchen

There are three components to this room — window, exterior wall and rear exterior door.

From Table 1: AIF = 35.

Bedrooms 1, 2 and 3

Each bedroom has three components — window, exterior wall and ceiling-roof.

From Table 1: AIF = 40.

Bathroom

There are three components to this room — window, exterior wall and ceiling-roof.

From Table 1: AIF = 30.

Appropriate components

It is necessary at this stage to calculate the percentage of the total window area, total exterior door area and the net exposed exterior wall area (i.e. excluding window and door areas) to the total floor area for each room. These percentages are:

Room	% Window area to total floor area	% Exterior wall area to total floor area	% Exterior door area to total floor area
Living room	17	44	11 (1)
Dining-kitchen	18	47	12 (2)
Bedroom 1	11	55	—
Bedroom 2	13	84	—
Bedroom 3	16	72	—
Bathroom	37	125	—

Notes: (1) The door area is the front exterior door only.
(2) The door area is the rear exterior door only.

By reference to Tables A to D determine the appropriate components.

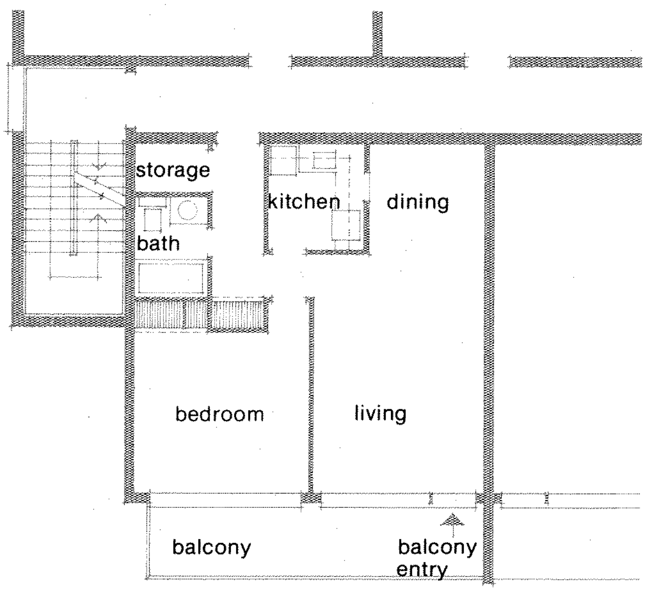
Summary

Dwelling: A 3-bedroom row house

Building location: 35 NEF

Room	Living	Dining-kitchen	Bed-room 1	Bed-room 2	Bed-room 3	Bath-room
Number of components	3	3	3	3	3	3
Acoustic Insulation Factor (Table 1)	35	35	40	40	40	35
% Window to floor area	17	18	11	13	16	37
% Exterior wall to floor area	44	47	55	84	72	125
% Exterior door to floor area	11	12	—	—	—	—
Appropriate components						
Windows (Table A)	2(35)2	2(42)2	2(63)2	2(80)2	2(100)2	2(28)2
Exterior walls (Table B)	EW1	EW2	EW4	EW4	EW4	EW1
Ceiling-roof (Table C)	—	—	C1	C1	C1	—
Exterior doors (Table D)	D2sd	D2sd	—	—	—	—

Example 4 A one-bedroom apartment
To determine the appropriate building components for this dwelling it is necessary to undertake calculations for the living room and the bedroom only, since the kitchen and the bathroom have no exterior components. The apartment, which is an end unit abutted by a stairwell, has windows across the full width of the bedroom. The living room has a solid door to the balcony.



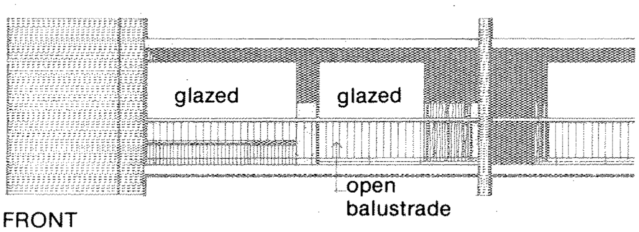


Figure 15. A one-bedroom apartment.

Building location
35 NEF

Acoustic Insulation Factors
Living-dining room
There are three components:
First component: window.
Second component: exterior wall, above the window and door.
Third component: door to balcony.
From Table 1: AIF = 35.

Bedroom
There are two components:
First component: window.
Second component: exterior wall, measured from the abutting corner of the stairwell to the living room.
From Table 1: AIF = 38.

Appropriate components
It is necessary at this stage to calculate the percentage of the total window area, total exterior door area and the net exposed exterior wall area (i.e. excluding window and door areas) to the total floor area for each room. These percentages are:

Room	% Window area to total floor area	% Exterior wall area to total floor area	% Exterior door area to total floor area
Living-dining	25	8	8
Bedroom	40	55	—

By reference to Tables A to D determine the appropriate components.

Summary
Dwelling: A one-bedroom apartment
Building location: 35 NEF

Room	Living-dining	Bedroom 1
Number of components	3	2
Acoustic Insulation Factor	35	38
% Window to floor area	25	40
% Exterior wall to floor area	8	55
% Exterior door to floor area	8	—
Appropriate components		
Windows (Table A)	2(50)2	2(150)2
Exterior walls (Table B)	EW1	EW3
Ceiling-roof (Table C)	—	—
Exterior doors (Table D)	D1sd	—

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