whole-house exhaust fans, and wall-mounted exhaust fans. Wall-mounted fans can have a baffle box installed, as shown in Figure 3–18, to limit the transmission of aircraft noise to the dwelling interior. All other air conditioners, fans, and ventilators should be removed and the surfaces repaired to match the existing conditions.

Table 3–16 summarizes the measures recommended to reduce noise and vibration in the dwelling ventilation system.

3.5.4.3 Bathrooms, Kitchens, and Fireplaces

Kitchen and bathrooms ventilation should not be connected to the air circulation system that serves the rest of the house. Most kitchens and bathrooms already have fans installed for ventilation purposes. If there is none, or if it is inadequate to provide five air changes per hour, an appropriate ventilator should be installed as needed.

Bathrooms

Bathrooms are not normally modified since they are not considered noise-sensitive rooms. If necessary, however, bathroom ventilators can be "muffled" with the insertion of a section of noise control flexible tubing so that there is no direct, unobstructed path from the exterior to the interior. This is illustrated in Figure 3–19. For wall-mounted ventilators, a "cross-talk" silencer, shown in Figure 3–18, may be used instead.

Kitchens

Kitchen ventilation fans can be modified in the same manner as bathroom fans, except for range cover exhaust hood. The exhaust hood never gets modified because doing so encourages the accumulation of grease or soot films in the vent and creates a serious fire hazard. Also, fiberglass must never be used in the ventilation ducts due to the fire hazard.

Fireplaces

Frequently, homes with fireplaces will require some type of modification. This is especially true if the outside noise exposure is high, or the fireplace is in a room used for watching TV. The treatment package consists of two parts: First, glass doors are mounted at the front of the fireplace. Second, a standard chimney-top damper is installed. The glass doors by themselves provide a noticeable improvement and these two treatments, in combination, have proven to be very effective at reducing noise entering on this path.

3.5.5 Manufactured Homes

Popularity

Manufactured homes are quite common in most areas of the country. There are two primary reasons for their popularity. They generally have a lower purchase price than similar conventional homes (though they are not much less expensive per square foot once their size is taken into account) and they can be bought and built more quickly than conventional housing. Local zoning ordinances restrict them in many areas but, as their appearance and structure conforms more to that of conventional homes, restrictions may be loosened and they may become more prevalent.

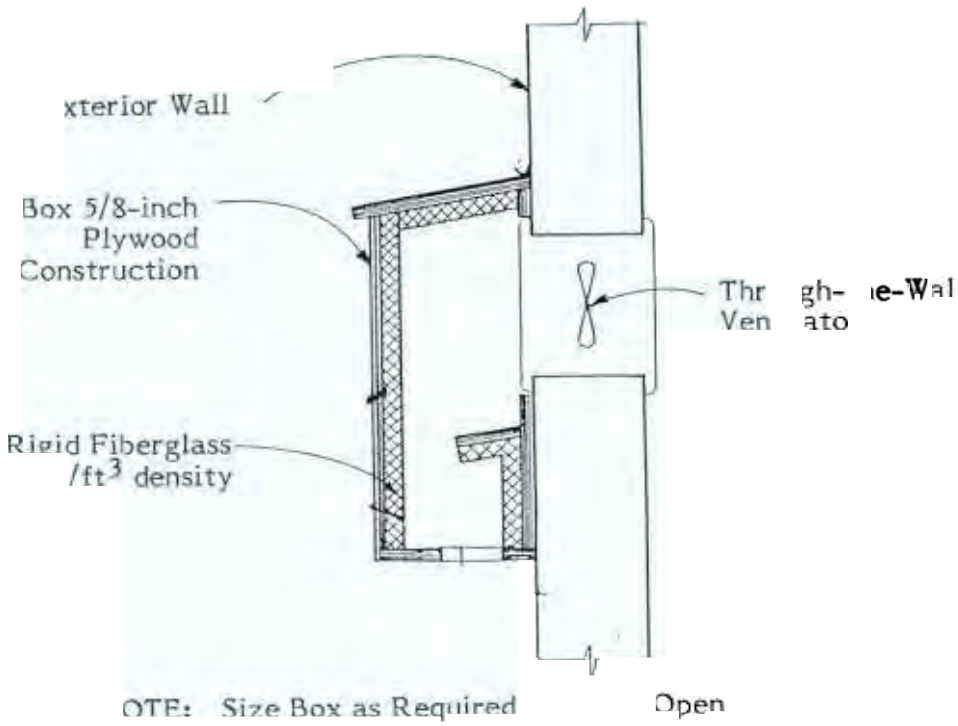
HUD Construction Standards

Since 1976 the manufactured housing industry has been closely regulated by the federal government. Factory-built homes must meet HUD standards for construction quality, energy efficiency, ventilation, and fire protection. These standards are expressed in HUD's "Mobile Home Construction and Safety Standards", published in 1975 and in force for models built since in 1976. Subsequent regulations and interpretations update this set of codes. The latest update was published in April 1988.

Comparison to Conventional Housing

Factory-built dwellings are available incorporating many of the features that buyers want in conventional homes. Wall constructions are similar to those found in site-built houses, including the exterior siding and interior finishes used. Manufacturers offer optional upgrades in thermal insulation, doors, and windows. Over the past several years the stereotyped picture of the metal-skin mobile home has been replaced by modular designs that are sometimes difficult to distinguish from what the industry calls "stick-built" dwellings.

Unfortunately, with respect to acoustical performance, there are still some significant differences, particularly in roof construction, air infiltration rates, and noise reduction of standard windows and doors. Recent improvements in



gur Baffl Box for Thr gh Wall Ventilator

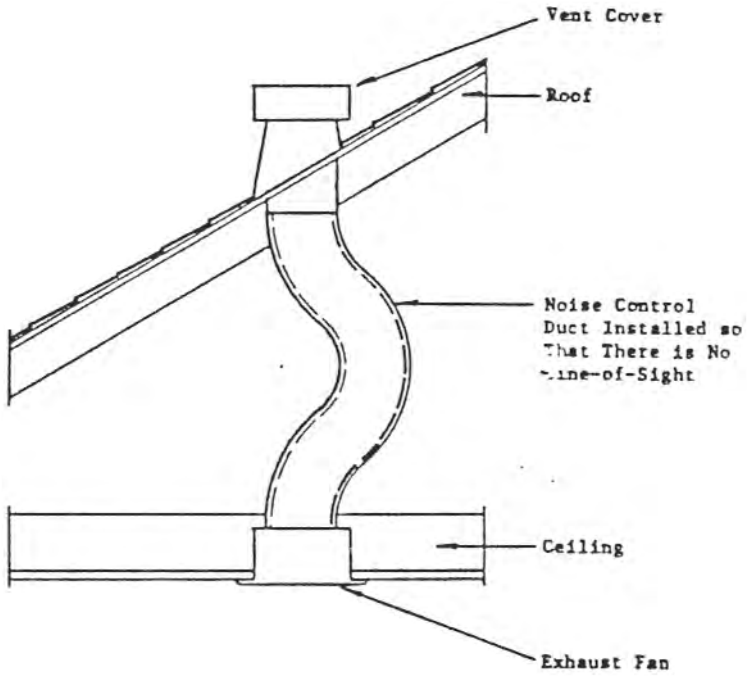


Figure 3-19. Bathroom/Kitchen Ventilator Modification.

construction materials and methods enhance the noise reduction somewhat but there are still many older homes in use with very poor sound insulation. The next section, Construction and Noise Reduction Properties, discusses typical factory-built construction elements and methods. The following section, Improving the Sound Insulation, describes the limited number of options available and their appropriate use. This information is provided primarily for residents and local officials. FAA guidelines generally do not provide for financial assistance to sound insulate manufactured homes because satisfactory results cannot be achieved at reasonable cost.

3.5.5.1 Existing Construction and Noise Reduction Properties

Variation in Construction

Since the introduction of federal standards for manufactured home construction there has been a trend toward more standardized materials and methods. Still, there are many older mobile homes in use and there are many different styles and customizing options available in newer units. Because of this diversity, it is difficult to detail any set of building elements that typifies factory-built homes. The sound-insulating performance can vary significantly depending on the age, model type, and general condition of the home. Manufactured homes tend to have certain features in common, however, which influence their noise reduction performance.

Roofs

From an acoustic point of view, one of the most significant features of factory-built housing is the consistent use of much lighter roofing than is normally found in other dwellings. Since the roof is fully exposed to aircraft noise, this presents serious problems. Many homeowners modify their roofs for thermal insulation, or to eliminate the annoying rattle associated with metal roofs. These measures, however, do not significantly improve the noise reduction. Figure 3–20 illustrates a typical factory-built roof construction.

As the figure shows, the roof pitch is lower than conventional roofs, leaving less space for insulating material and a smaller buffer zone for trapping and absorbing noise. The ceiling insulation rating varies depending on the age of the home and the options the owner chose when purchasing it. Prior to the HUD standards in 1976 there were widely varying state regulations in place. Homes built before 1976 normally used R–7 insulation. Since the 1976 standards, homes must have at least R–11 rated thermal insulation and R–19 is most common.

While many roofs are metal covered, models using asphalt or fiberglass shingles are available. One advantage of newer factory-built homes is the use of a large single piece of gypsumboard for the finish ceiling, eliminating joint leaks. However, a 1979 HUD study, PDR-636, "Thermal Envelope Systems Test Report", found significant air infiltration around the ceiling perimeter where it meets the walls. Part of the reason for seam infiltration is uneven settling of the home on its supports. This is especially true of double- and triple-wide models. The ceiling seams between the modular units separate if the home is not level.

Walls

The wall construction varies considerably depending on the age and model of the home. Figure 3–21 shows schematically two common assemblies. Early models employed a sheetmetal skin with attached structural members. The air cavity often had a layer of styrofoam insulation inside. A sheet of thin (5/32 inch) hardboard luan paneling was stapled on as the interior finish. Recent housing surveys found many older mobile homes of this type still in use, though they are slowly being replaced by more modern designs.

Newer models feature wood, vinyl, or aluminum siding mounted to 2x4–inch studs, as in conventional construction. Sometimes the siding is attached to the studs with a layer of thermal sheathing between. Most often, it is mounted directly, without an intermediate layer. Wall cavity insulation is usually R–7 batts or blown–in, though higher grades are available and more common in the north. In addition, many models in the north have 2x6–inch sidewall studs. The interior finish is likely to be gypsumboard.

In 1985 a HUD study of formaldehyde outgassing from particleboard and decorative paneling prompted regulations governing allowable formaldehyde levels. These standards drove the industry away from the use of the thinner paneling toward gypsumboard. Actually, consumer demand had already encouraged a shift toward using drywall in the early 1980s. The formaldehyde problem, however, eliminated heavy reliance on particleboard, hardboard luan, and urea products. A 1988 study performed by the Manufactured

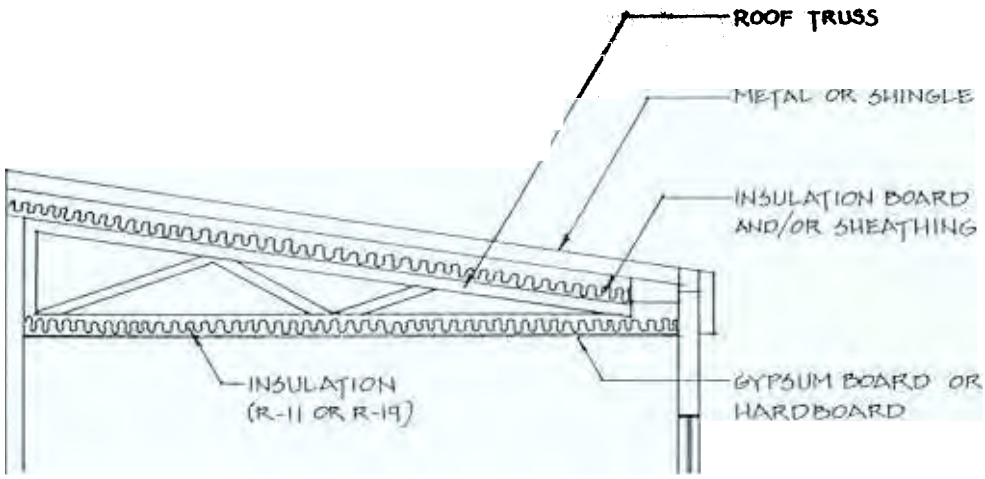
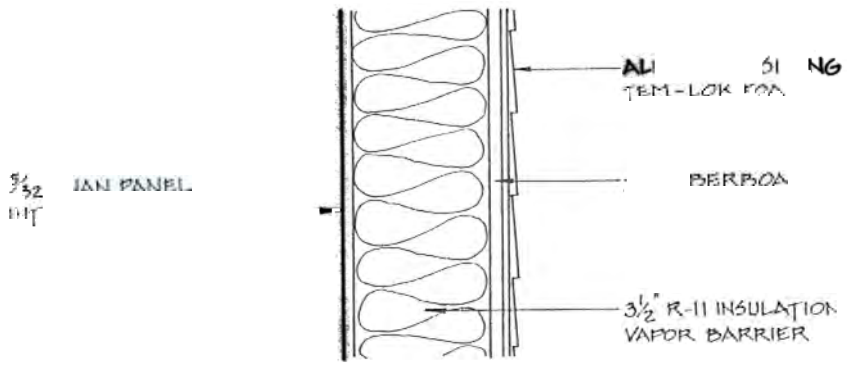
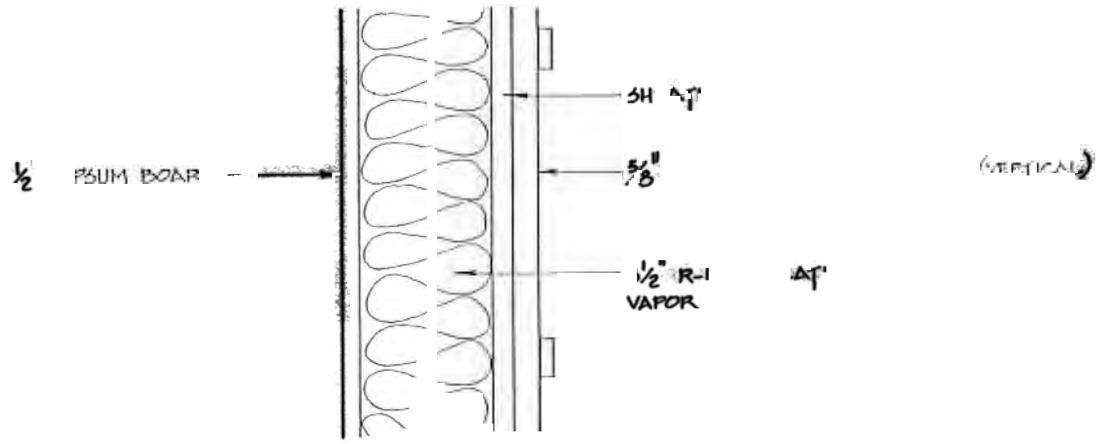


Figure 3-20. Roof Construction of a Manufactured Unit: One-Half of a Double-Wide Dwelling.



(a) Typical Pr 985 Mobil H



(b) Typical Cu Ma ufa tu ed H

Figu -2 Typical Manufa tu ed H Wall Constru

Housing Institute showed that 95 to 98 percent of current factory-built homes use gypsumboard walls and ceilings. Gypsumboard is heavier and provides better acoustic insulation than earlier materials. It also has superior flame-retardant properties, provides added stability and is easier to decorate.

Some factory-built homes have vented air cavities in the wall construction. These vents at the bottom of the wall provide a ready path for noise transmission into the dwelling. Fortunately, this construction scheme does not seem very common. Another, more common, path for air and sound infiltration is the gap left open at the wall bottom where the corrugated siding does not seal completely with the deck. The 1979 HUD study on thermal envelope performance, mentioned above, found air infiltration to be a problem at most joining points and openings in the mobile home walls.

Floors

The design of manufactured dwelling floors has been governed by loading requirements peculiar to a house which may travel 800 miles before resting on its foundation. There are actually two types of manufactured homes in use; true modular units which are transported on a truck and lifted into place by a crane, and mobile modular units which are built with removable hitch, axles, and wheels. Most older models are of this second kind.

Two basic under-floor structural support systems are available in manufactured homes. One uses a wood deck supported by a steel underframe. The alternative, which is gaining popularity, is a unified floor system based on a strong wood beam truss. Both will typically use a plywood floor over insulating material, covered with carpeting or multi-purpose tile. Hardboard sheathing normally seals the underside. Unfortunately, air-conditioning, plumbing, and other improvements can only be installed through the floor and this often degrades the sub-floor noise attenuation by leaving openings there.

Windows and Doors

The windows in manufactured homes are almost always insufficient for good sound attenuation. They are normally single-pane assemblies, though double and triple glazed systems are available. As Section 3.5.2.1 explained, multiple glazing in thermal windows is rarely effective for cutting down noise since the panes are too close together. Poor quality control of weatherstripping and caulking will aggravate the sound transmission problems. Storm windows, which come as standard equipment on homes in cold winter climate areas, will improve the noise reduction somewhat but are mounted too close to provide optimum relief.

Doors on manufactured homes are typically comprised of either a steel exterior with a foam insulation core or sheetmetal with a corrugated honeycomb cardboard core. The steel doors with the foam core seem to provide better sound attenuation and, if not standard, are available as factory-installed options or as home improvements.

Sliding glass doors are constructed similarly to those found in conventional homes, though they are often smaller. Most use aluminum frames, but wood is also popular. They have the same problems as sliding glass doors in site-built homes, generally being weaker sound insulators than the surrounding wall.

Homes built prior to 1985 may have significant problems with air leakage around doors and windows. Since that date, standards issued by the American Architectural Manufacturers Association (AAMA) have specified compliance with leakage limits based on ASTM testing methods. The applicable standards are: for doors, AAMA 1702.2-1985; for windows and sliding glass doors, 1701.2-1985; and for egress windows, 1704-1985. Recent Manufactured Housing Institute tests indicate significant improvements in leakage problems with conformance to these standards.

Assembly Methods and Quality Control

In the factory, the walls, floor, and roof are built as units and joined with metal straps and fasteners to form the house. Ideally, this method should provide a good seal. And one of the selling points of these homes is the assurance that closer supervision in a factory environment gives better quality control. Unfortunately, this is not always the case. The 1979 HUD thermal envelope tests on two standard, new, mobile homes documented significant air infiltration at the wall edges, door edges, vents, windows, and under the floor. They found improperly installed weatherstripping. In general, the testing team concluded that the lack of appropriate quality control during construction significantly increased the air infiltration of the dwelling.

Since these tests were performed there have been revisions of some standards, leakage limits have been imposed, and consumers have been demanding higher quality. Manufacturers have responded to these pressures and corrected some of the problems cited. Homes built prior to the mid-1980s, however, still suffer from these weaknesses.

Ventilation

One advantage of factory-built houses is the fact that most use ducted ventilation systems. A ducted air system is a prerequisite for proper climate control and air circulation since the windows and doors must be kept closed for sound insulation. In general, HUD requires the same ventilation and light specifications for manufactured homes as other codes require for conventional housing. These requirements include:

- One air change per half hour (or two per hour);
- A 20 percent, or one-fifth, mix of fresh air;
- Glazed openings for natural light in each room with an area equal to 8 percent of the floor area;
- Kitchens may have artificial light.

Manufactured homes vary as much as conventional homes in the type of ventilation systems currently in use. The fresh-air make-up is more common in forced-air systems or as an intake to the furnace when that is in operation. A Commerce Department study of typical constructions found that 50 percent of all manufactured homes nationally have air-conditioning. The percentage in any specific geographical area ranges from 80 percent in the south to about 40 percent in the north. Optional use of the fan without heating or cooling, an important facility when the windows and doors must be closed year-round, is not normally provided.

Measured Noise Reduction Values

Recent exterior and interior noise measurements of a typical mobile home and modular factory-built home near Seattle indicate that the "as is" noise reduction levels are slightly lower the average of homes tested in that Seattle study. Table 3-17 shows the noise reduction values for the major habitable rooms of these homes along with the project average.

3.5.5.2 Improving the Sound Insulation

Due to the lighter construction of many manufactured homes, the sound insulation options are usually limited to window and door replacement and some minimal wall modifications. When a homeowner buys a manufactured home they are provided with a consumer handbook. This handbook gives valuable information regarding the maintenance and repair of their home. It usually describes window attachment schemes, siding type and attachment, ventilation duct networks, and other topics useful in sound insulation. Copies are almost always available from the manufacturer.

Roofs

The walls and ceiling/roof assembly are comparatively weak, structurally, and so are not as readily altered as in conventional dwellings. During a sound insulation project near Seattle, roof modifications were recommended for a mobile home and a modular prefabricated home but could not be installed. In both cases, the walls would not support the increased weight of the improved roof. As a result, the dwellings could not be brought to a condition which satisfied the noise reduction requirements.

If there is ready access to the attic space, the attic insulation can be improved. The primary interest here is to provide material to absorb sound reverberating in the space, not to block it. In most cases R-19 is sufficient, though some benefit is gained by upgrading as far as R-30. The peak height is generally no greater than 35 inches, which, along with weight limits, prevents more effective treatments. Most double- and triple-wide homes allow access to the attic space, as do homes with active attic ventilation systems. Attics are not usually accessible in single-wide homes.

If there is a skylight in place, it should be removed and the roof repaired to match the existing condition.

Walls

Greater sound attenuation through the walls is achieved by adding mass to either the outside or the inside. On many mobile homes, particularly those with aluminum or wood siding, the exterior panels are removable for maintenance and repair. This makes it very easy to take down the panels, mount a layer of sheathing or sound-deadening

Table 3-17

Noise Reduction Improvements in Major Habitable Rooms

Room Category	Mobile Home[1]			Pre-Fabricated Home[2]			Study Average[3]		
	Before	After	Improv't	Before	After	Improv't	Before	After	Improv't
Living Room	26.9	29.5	2.6	28.9	28.1	-0.8	27.7	32.3	4.6
Kitchen	27.2	32.5	5.3	26.2	26.3	0.1	27.3	32.9	5.6
Bedroom 1	34.0	35.2	1.2	27.9	31.6	3.7	30.2	34.5	4.3
Bedroom 2	27.3	29.1	1.8	32.1	32.3	0.2	--	--	--

[1] Mobile Home modifications consisted of installing STC 45 dB windows on all exposed facades, STC 35 main door, and secondary sliding glass door. Gypsumboard was added to the unshielded living room and bedroom #1 walls.

[2] Pre-Fabricated Home modifications included adding gypsumboard to walls in living room and bedroom #1, installing STC 35 windows and STC 40 door in kitchen, adding STC 35 or secondary STC 30 windows in other rooms.

[3] Modification in study included those discussed above plus other wall and roof improvements.

board, and then replace the siding. This is probably the preferred treatment in the majority of cases since it avoids inconveniencing the homeowner and taking away any of the interior floor space.

Where this is infeasible – for homes with vinyl siding which is not easily removed, for example – similar results can be attained by treating the dwelling interior. This is accomplished by removing the interior finish paneling, attaching an extra layer of gypsumboard or sound-deadening board to the studs, and reattaching the interior finish material. In either case, the walls should be examined to ensure they will support the weight of the additional material.

Windows and Doors

Acoustic windows and doors have been installed successfully in manufactured homes. Because the walls and roof are so light, it is usually necessary to specify the highest possible STC-rated products in order to appreciably reduce the interior noise level. In most cases the windows can be replaced from the outside. Secondary windows, mounted at least 2 inches away from the primary windows, have also been used with good results. The acoustic performance of sliding glass doors can be improved by building a secondary sliding glass door, mounted on 2x4 studs, at least 2 inches outside the primary door. Storm windows are frequently used on factory-built homes as well. They should be installed with caution on emergency egress windows since they make escape during a fire more difficult.

Air Infiltration

There are a number of steps to be taken to correct air infiltration problems. A close inspection of the external envelope, including the underside, should reveal any gaps or openings to be sealed. This is often a problem around plumbing and appliance access sites and around improperly installed vents. The vents themselves can be baffled using the techniques described in Section 3.5.4.

Older homes may need considerable attention to gaps and leaks around windows, doors, and seams. Newer models, subject to the AAMA leakage standards, are less likely to have problems here. Weatherstripping should be repaired or replaced, as needed. Multiple-module homes should be checked for separation at the seams resulting from uneven settling of the units. The home should be leveled if necessary and the seams repaired and sealed.

Ventilation

The ideal ventilation system, as described in Section 3.5.4, provides air replenishment and circulation, with heating or cooling as needed, through a system of ducts. The measures required to bring the existing system into conformance with this will depend on the type of system in place.

Most manufactured homes feature environmental systems supplied by a few large companies. These companies usually offer packages to upgrade to their systems which satisfy almost all these requirements. The only feature which is not always available is the option to run the fan with replenished air when the heating and air-conditioning are not operating. Refer to Section 3.5.4 for a more complete treatment of ventilation.

Noise Reduction Improvements

If all these measures are used together, a noise reduction of from 1 to 5 dB can be expected. This is considerably lower than the improvements attained when roof modifications and more effective wall modifications are possible.

Table 3–18 presents a summary of modifications for improving the noise reduction of manufactured homes.

Table 3-18

Summary of Methods for Improving Noise Reduction in Manufactured Homes

Roofs:

1. Upgrade attic insulation to R-19, or better, where feasible.
2. Remove skylight and repair roof to existing condition.

Walls:

3. Add mass under exterior siding, or under interior decorative finish surface, by mounting sheathing, gypsumboard, or sound-deadening board.

Windows and Doors:

4. Mount secondary windows and sliding glass doors at least 2 inches away from existing elements on the dwelling exterior.
5. Replace existing windows and doors with highest STC rated products available.

Air Infiltration Paths:

6. Seal gaps and openings in external envelope.
7. Baffle vents.
8. Repair or replace weatherstripping.
9. Check and repair seals between modular units in double and triple-wide homes. Re-level home if necessary to prevent recurring problem.

Ventilation:

10. Upgrade existing system, as necessary, to provide air replenishment, circulation, heating and/or cooling to enable homeowner to keep windows and doors closed year-round.

3.6 Cost Estimation

This section discusses the process of choosing between various noise reduction options. It includes sample improvement packages and costs per square foot for insulating 26 dwelling types. In addition to the costs given for the modifications packages, cost multipliers are given for different regions of the country, and for new versus remodeled construction. A detailed example shows how to use the modifications and cost factors to develop rough cost estimates for home sound insulation construction.

3.6.1 Estimating Insulation Required

Design Criteria

In order to meet the noise reduction goals, a package of modifications is designed for each eligible house. The goals are defined using predicted DNL noise exposure and the recommended noise reduction for that exposure zone. An SEL criteria may also be used to supplement the DNL guided NLR. There are two ways to determine the existing sound insulation condition of the house. One is by taking field measurements in the house, as described in Section 3.3. The other is by calculating the noise reduction for each room from the building component EWR or STC ratings. A computerized cost optimization program with a data base of EWR or STC ratings for typical construction elements and methods is a useful tool for such calculations. Which modifications will comprise the design package, of all the possible options, depends on which combination best meets certain requirements. The design must be:

- Capable of providing the necessary NLR improvement;
- Practical, installable in the particular house;
- Cost effective;
- Acoustically balanced;
- Aesthetically acceptable to the homeowner.

Example of Balancing the Design Criteria

These aims may conflict at times and must be balanced during the design phase of the project. To illustrate this process, consider the house belonging to a resident of Oak Harbor in Washington State. Her single-story house is very typical of homes across the country and is described by the floor plan in Figure 3-22. Assume that the back of this aluminum siding house is shielded from the flight track. It features a vented attic and sits on a crawlspace. The windows have 1/8-inch-thick single panes of glass and use aluminum frames. Her front door is the standard wooden hollow-core type.

The resident lives within the 65 to 70 dB DNL contour zone so, using Table 1-1, the noise reduction in all habitable rooms must be improved to 25 dB. Assume that field measurements show that the existing NLR in the living room is 18 dB. The living room faces the flight track and is not shielded in any way from the aircraft noise. Subtracting the existing NLR (18 dB) from the required NLR (25 dB) indicates that the sound insulation performance must be improved by 7 dB.

Example calculation:

Exterior Noise Level	= 70 dB
Required Noise Reduction	= 25 dB
Measured Existing Noise Reduction	= 18 dB
Required Improvement	= 7 dB

Each room in the home will be examined in this way to determine the necessary improvement in NLR. A design will be developed to modify the dwelling and install sound-insulating materials to meet the NLR goal. This can be achieved in a variety of ways, and the acoustic consultant preparing the design will consider all the requirements stated above.

Improving the windows and doors first usually nets the best results for the least cost. But optimizing the cost must be balanced against other considerations. Suppose the most cost-effective solution for the living room is to replace the front window and door with specialized acoustic ones and to mount a secondary window outside the window on the other side of the room. The homeowner will probably reject this configuration because she wants all the windows in her living room to look the same. Most design packages take the aesthetic acceptability into account and aim for a uniform appearance of all the windows in a room. This may also be extended to ensure that all windows on a given side of the house look alike.

Suppose that the designer recommends acoustic baffles for the attic vents. This is a useful modification in many homes. Unfortunately, most baffles are made in a rectangular shape and the attic may have triangular vents. If so, the selected

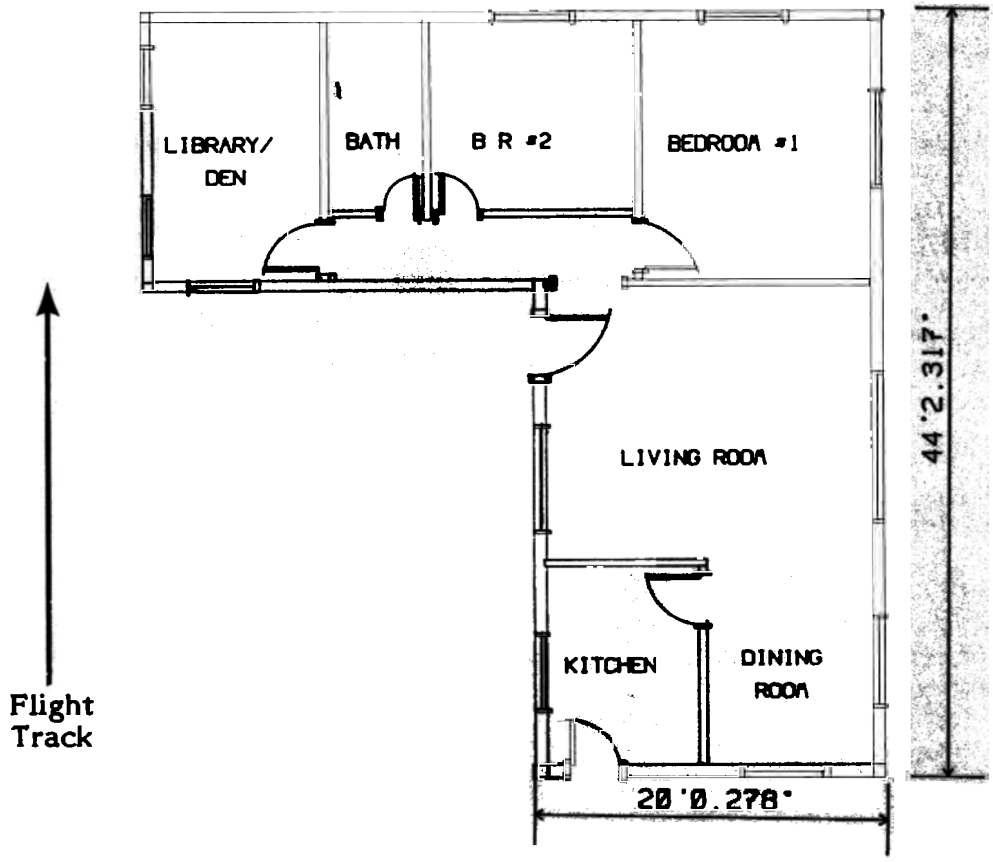


Figure 3-22. Sample Single-Story Dwelling.

option cannot be installed without modifying the wall to accommodate the different shape. It may be more practical to add insulating batts to the attic instead. Another option would be installing the baffles to the underfloor crawlspace vents which are already rectangular.

For a final example, if the resident lives in a higher noise zone she may need more sound insulation in her kitchen than even the very best acoustic windows and doors can provide. In any other room of her house the acoustic consultant could choose to add a layer of sound-deadening board and gypsum wallboard to the interior finish wall. But, because the kitchen walls have cabinets and tile on them, this normally effective option cannot be exercised. Here, the designer may have to improve the windows and the door, then go a step further and modify the ceiling to achieve the noise reduction goal.

This illustration demonstrates the complexity of deciding how to sound insulate a home and indicates some of the factors involved. Two houses may be very much alike and yet each will have unique features which require special treatment. While it is useful to discuss, in general terms, typical dwelling categories and classes of modifications, the actual site-specific design requires the services of an acoustics consultant or an acoustics-knowledgeable architect.

Modifying Categories of Dwellings

For rough costing purposes, however, it is valid to determine common dwelling categories and the types of modifications that can be expected, in general, to satisfy the noise reduction goals. Toward this end, 26 home types have been selected as representative of many houses across the country. Table 3–19 gives this list of homes. The choice ranges from siding to brick, stucco, concrete, and manufactured housing. Most of the homes on the list are single-story dwellings but two double-story houses and three multi-level townhomes have been included. The features identified for each home are those that have the greatest influence on noise reduction performance. The construction details are the same as those noted on the Housing Inventory Worksheet, Figure 3–2. For these purposes, all types of siding, including aluminum, wood, and vinyl, are treated the same.

A computerized sound insulation cost-optimization program has been used to examine each case for all four noise zones. Each house is treated room by room and a set of modifications is developed to meet the NLR goal. Other considerations entered into the design as well. For example, if one room needed attic insulation to improve the insulation performance, then all rooms get attic insulation. It is not practical to selectively insulate parts of the attic. The overall design of the other rooms is then rebalanced for the lowest cost required to meet the NLR target. A minimum NLR improvement of 5 dB was enforced to ensure that the homeowner would be able to perceive the NLR increase.

Modification Tables and Results

Table 3–20 defines the modification codes used in the computerized cost estimates. Then, Tables 3–21 through 3–46 outline a package of reasonable modifications which would satisfy the interior noise goals for DNL exposures of 65 dB, 70 dB, 75 dB, and 80 dB. Each table takes one of the 26 house types and lists the modifications suggested in each room to achieve the noise reduction goal.

The first column tells which room is being modified. Not all rooms need insulation improvements. In order for the modifications to be effective, all of the treatments listed for all rooms must be carried out. In the "Building Element" column appears "NR BEFORE", followed by individual building elements and "NR AFTER". "NR BEFORE" and "NR AFTER" give the computer predicted noise reductions of the room before and after the modifications are implemented. These values are based on EWR ratings for the building elements used.

The building elements listed are on the exterior wall only, plus the ceiling or roof and floor. Modifications to interior walls and doors do not improve the aircraft noise protection. Where there is more than one exterior wall or window, these will be numbered: Wall 1, Wall 2, Window 1, and Window 2, etc. To the right of the element name is the specific modification to be applied to it. These modifications are chosen depending on the noise exposure zone and the noise reduction goals given in Tables 1–1 and 1–2. The modifications become more extensive, and more costly, as the outside noise exposure increases.

If a block is empty, as many are for the 60–65 dB zone, then no modifications were required. The modification packages listed here are chosen from numerous optional combinations of materials and methods. Other choices might work as well. The final customized design should

Table 3-19

Table of Housing Configurations Used in EWR Cost Optimization Program

Ident.	Ext. Wall	Roof	Window	Foundation	Door
One-story Houses:					
A	Stucco	VA	AL; 1/8 oper.	Crawl	SC
B	"	SJL	1/8 dual pane	Slab	SC
C	Brick	VA	AL; 1/8 oper.	Slab	SC
D	"	VA	1/8 dual pane	Basement	SC
E	"	VA	1/8 dual pane	Slab	SC
F	"	SJL	1/8 dual pane	Crawl	SC
G	"	SJH	1/8 dual pane	Crawl	SC
H	"	VA	1/8 oper.	Crawl	SC
I	Siding	VA	1/8 dual pane	Basement	SC
J	"	VA	1/8 oper.	Crawl	SC
K	"	VA	1/8 oper.	Slab	SGD
L	"	ECL	Jalousie	Slab	SGD
M	"	VA	1/8 oper.	Slab	SC
N	"	SJL	1/8 dual pane	Slab	SC
O	"	SJL	1/8 oper. w/st.	Basement	SC
P	"	ECL	1/8 dual pane	Crawl	SC
Q	"	SJL	1/8 oper.	Slab	SGD
R	Block	VA	AL; 1/8 oper.	Slab	SC
S	Concrete	VA	1/8 dual pane	Crawl	SC
T	"	SJL	1/8 dual pane	Crawl	SC
Manufactured Home:					
U	Siding	VA	1/8 oper.	Crawl	HC
Two-story Townhouses:					
V	Siding	VA	1/8 dual pane	Basement	SGD
W	Brick	VA	"	"	SGD
End Unit Townhouse:					
X	Siding	VA	1/8 dual pane	Basement	SGD
Two-story Detached Dwelling:					
Y	Siding	VA	1/8 dual pane	Basement	SC
Z	Brick	VA	"	"	SC

Notes:
- Where there is a sliding glass door (SGD), the other exterior door is solid core (SC).
- One side of all dwellings is "shielded", usually the back side.

VA = Vented Attic
SJL = Single Joist, Light
ECL = Exposed Ceiling, Light

SC = Solid Core Door
HC = Hollow Core Door
SGD = Sliding Glass Door

Table 3-20

Housing Modification Description Codes

Door Modifications	Description
SC+SEald	Solid Core + Vinyl Bulb Seal
SC+WSTRP	Solid Core + Weatherstrip
SC+SE+ST	Solic Core + Vinyl Bulb Seal + Storm Door
SG+WSTRP	Sliding Glass + Weatherstrip
RSTC35	Door having an STC Rating of 35
RSTC40	Door having an STC Rating of 40
RSTC45	Door having an STC Rating of 45
HC+STORM	Hard Core + Storm Door
HC+WS+ST	Hard Core + Weatherstrip + Storm Door

Window Modifications	Description
8p+STORM	1/8-inch Pane + Storm Window
8p+STC25	1/8-inch pane + Window having an STC Rating of 25
RSTC35	Window having an STC Rating of 35
RSTC40	Window having an STC Rating of 40
RSTC45	Window having an STC Rating of 45

Wall Modifications	Description
STUC+GYP	Stucco + 5/8-inch Gypsumboard
STUC+2GY	Stucco + 2 Layers Gypsumboard
STUC+MG	Stucco + Metal Stud + Gypsumboard
STUC+MGA	Stucco + Metal Stud + Gypsumboard + Absorption
WDGY+GYP	Wood/Gyp + 5/8-inch Gypsumboard
WDGY+2GY	Wood/Gyp + 2 Layers Gypsumboard
WDGY+RGA	Wood/Gyp + Resilient Chan. + Gypsumboard + Absorption
WDGY+MG	Wood/Gyp + Metal Stud + Gypsumboard
WDGY+MGA	Wood/Gyp + Metal Stud + Gypsumboard + Absorption
HBLK+GYP	Hollow Block + Gypsumboard
HBLK+2GY	Hollow Block + 2 Layers Gypsumboard
HBLK+RGA	Hollow Block + Resilient Chan. + Gypsumboard + Absorption
HBLK+MGA	Hollow Block + Metal Stud + Gypsumboard + Absorption
BRIK+GYP	4-inch Face Brick + Gypsumboard
BRIK+2GY	4-inch Face Brick + 2 Layers Gypsumboard
BRIK+MG	4-inch Face Brick + Metal Stud + Gypsumboard
BRIK+MGA	4-inch Face Brick + Metal Stud + Gypsumboard + Absorption

Roof Modifications	Description
VP+Absrp	Vented Pitched + Absorption
VP+Ab+GY	Vented Pitched + Absorption + Gypsumboard
SJL+GYP	Single Joist (Light) + Gypsumboard
SJL+A+RG	Single Joist (Light) + Resilient Chan. + Gypsumboard
ELt+GYP	Exposed Ceiling (Light Joist) + Gypsumboard
EL+Ab+GY	Exposed Ceiling (Light Joist) + Absorption + Gypsumboard
EL+Spc B	******** Needs Clarification ********

Floor Modifications	Description
FB+A+STd	Floorboard + Absorption + Storm Door (Basement)

Table 3-21
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type A

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	19.8	19.8	19.8	19.8
	Door 1		SC+SEald	RSTC35	RSTC40
	Window 1		RSTC45	RSTC45	RSTC45
	Window 2 *			RSTC35	RSTC45
	Wall 1				STUC+MGA
	Wall 2 *				STUC+MG
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	19.8	24.9	30.4	34.9
Dining Room	NR BEFORE	21.0	21.0	21.0	21.0
	Window 1 *		8P+STC25	RSTC35	RSTC40
	Window 2		8P+STC25	RSTC45	RSTC45
	Wall 1 *				STUC+2GY
	Wall 2				STUC+MGA
	Roof 1		VP+Absrp		VP+Absrp
	Floor 1				
	NR AFTER	21.0	25.4	30.0	34.8
Kitchen	NR BEFORE	18.7	18.7	18.7	18.7
	Door 1	SC+SEald	SC+SEald	RSTC40	RSTC40
	Window 1	RSTC35	RSTC40	RSTC45	RSTC45
	Wall 1				
	Roof 1		VP+Absrp		VP+Absrp
	Floor 1				
	NR AFTER	24.2	24.7	28.7	29.7
Bedroom #1	NR BEFORE	23.2	23.2	23.2	23.2
	Window 1 *		RSTC35	RSTC35	RSTC35
	Window 2		RSTC35	RSTC40	RSTC45
	Wall 1 *				STUC+GYp
	Wall 2				STUC+MGA
	Roof 1		VP+Absrp		VP+Absrp
	Floor 1				
	NR AFTER	23.2	30.1	30.4	34.1
Bedroom #2	NR BEFORE	23.0	23.0	23.0	23.0
	Window 1		RSTC35	RSTC40	RSTC45
	Wall 1				STUC+GYp
	Roof 1		VP+Absrp		VP+Absrp
	Floor 1				
	NR AFTER	23.0	30.2	31.0	34.0
Library/Den	NR BEFORE	19.5	19.5	19.5	19.5
	Window 1		RSTC35	RSTC45	RSTC45
	Wall 1			STUC+GYp	STUC+GYp
	Roof 1		VP+Absrp		VP+Absrp
	Floor 1				
	NR AFTER	19.5	26.7	30.5	31.5
Cost Per Dwelling Sq. Ft.	C/D. Sq.Ft.	$0.34	$6.40	$10.18	$15.65

* 5 dB shielding assumed.

Table 3-22
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type B

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.0	21.0	21.0	21.0
	Door 1		SC+SEald	RSTC35	RSTC40
	Window 1		RSTC35	RSTC35	RSTC45
	Window 2 *		RSTC35	RSTC35	RSTC45
	Wall 1			STUC+GYP	STUC+RGA
	Wall 2 *				STUC+RGA
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	21.0	25.9	31.8	35.8
Dining Room	NR BEFORE	23.0	23.0	23.0	23.0
	Window 1 *		RSTC40	RSTC35	RSTC45
	Window 2		RSTC40	RSTC35	RSTC40
	Wall 1 *		STUC+GYp		STUC+2GY
	Wall 2				STUC+2GY
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	23.0	28.4	30.8	35.0
Kitchen	NR BEFORE	19.4	19.4	19.4	19.4
	Door 1		SC+SE+ST	RSTC40	RSTC40
	Window 1		RSTC35	RSTC45	RSTC45
	Wall 1				
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	19.4	24.8	30.0	30.0
Bedroom #1	NR BEFORE	24.6	24.6	24.6	24.6
	Window 1 *		RSTC35	RSTC35	RSTC40
	Window 2		RSTC35	RSTC35	RSTC40
	Wall 1 *				STUC+RGA
	Wall 2				STUC+2GY
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	24.6	28.1	31.7	35.3
Bedroom #2	NR BEFORE	24.5	24.5	24.5	24.5
	Window 1		RSTC35	RSTC35	RSTC40
	Wall 1				STUC+2GY
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	24.5	28.3	31.9	35.4
Library/Den	NR BEFORE	21.5	21.5	21.5	21.5
	Window 1		RSTC35	RSTC35	RSTC45
	Wall 1			STUC+GYp	STUC+RGA
	Roof 1			SJL+A+RG	SJL+A+RG
	Floor 1				
	NR AFTER	21.5	26.4	30.1	35.0
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$7.29	$11.33	$17.46

* 5 dB shielding assumed.

Table 3-23
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type C

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	19.9	19.9	19.9	19.9
	Door 1		SC+SE+ST	RSTC35	RSTC40
	Window 1		RSTC35	RSTC35	RSTC45
	Window 2 *			RSTC35	RSTC40
	Wall 1				BRIK+GYP
	Wall 2 *				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	19.9	25.0	30.3	35.3
Dining Room	NR BEFORE	21.3	21.3	21.3	21.3
	Window 1 *		8P+STC25	RSTC35	RSTC40
	Window 2		8P+STC25	RSTC35	RSTC45
	Wall 1 *				
	Wall 2				BRIK+2GYP
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	21.3	25.9	30.7	36.1
Kitchen	NR BEFORE	19.0	19.0	19.0	19.0
	Door 1	SC+SE+ST	SC+SEald	RSTC35	RSTC40
	Window 1	8P+STorm	RSTC35	RSTC40	RSTC45
	Wall 1				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	23.7	25.1	32.2	35.1
Bedroom #1	NR BEFORE	23.6	23.6	23.6	23.6
	Window 1 *		RSTC35	RSTC35	RSTC40
	Window 2		RSTC35	RSTC35	RSTC40
	Wall 1 *				
	Wall 2				BRIK+MGA
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	23.6	31.6	32.5	35.8
Bedroom #2	NR BEFORE	23.3	23.3	23.3	23.3
	Window 1		8P+STC25	RSTC35	RSTC40
	Wall 1				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	23.3	27.8	32.4	35.6
Library/ Den	NR BEFORE	19.9	19.9	19.9	19.9
	Window 1		8P+STC25	RSTC35	RSTC45
	Wall 1				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	19.9	24.6	29.4	35.9
Cost Per Dwelling Sq.Ft.	C/D. Sq. Ft.	$0.22	$4.45	$8.33	$12.11

* 5 dB shielding assumed.

Table 3-24
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type D

Room	Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.5	21.5	21.5	21.5
	Door 1		SC+SE+ST	RSTC35	RSTC40
	Window 1		8G+STC25	RSTC40	RSTC45
	Window 2 *		8G+STC25	RSTC40	RSTC40
	Wall 1		BRIK+GYp		BRIK+MGA
	Wall 2 *				BRIK+RGA
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	21.5	26.9	32.0	34.6
Dining Room	NR BEFORE	24.1	24.1	24.1	24.1
	Window 1 *			RSTC40	RSTC45
	Window 2			RSTC40	RSTC45
	Wall 1 *				
	Wall 2				BRIK+MGA
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	24.1	24.1	33.8	36.1
Kitchen	NR BEFORE	19.9	19.9	19.9	19.9
	Door 1		SC+SEald	RSTC35	RSTC40
	Window 1		RSTC40	RSTC40	RSTC45
	Wall 1				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	19.9	25.6	31.9	34.4
Bedroom #1	NR BEFORE	26.2	26.2	26.2	26.2
	Window 1 *			8G+STC25	RSTC40
	Window 2			8G+STC25	RSTC45
	Wall 1 *				
	Wall 2				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	26.2	26.2	30.7	35.8
Bedroom #2	NR BEFORE	26.0	26.0	26.0	26.0
	Window 1			8G+STC25	RSTC40
	Wall 1				BRIK+MG
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	26.0	26.0	30.5	35.0
Library/Den	NR BEFORE	22.7	22.7	22.7	22.7
	Window 1		8G+STC25	RSTC40	RSTC45
	Wall 1				
	Roof 1			VP+Absrp	VP+Absrp
	Floor 1				
	NR AFTER	22.7	27.2	32.8	35.1
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$3.23	$8.97	$12.96

* 5 dB shielding assumed.

Table 3-25
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type E

Room	Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.6	21.6	21.6	21.6
	Door 1		SC+SE+ST	RSTC35	RSTC35
	Window 1		8G+STC25	RSTC35	RSTC35
	Window 2 *		8G+STC25	RSTC35	RSTC40
	Wall 1		BRIK+GYP		BRIK+2GYP
	Wall 2 *				BRIK+GYP
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	21.6	27.0	32.1	35.4
Dining Room	NR BEFORE	24.1	24.1	24.1	24.1
	Window 1 *			RSTC35	RSTC35
	Window 2			RSTC35	RSTC35
	Wall 1 *				BRIK+GYP
	Wall 2				BRIK+GYP
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	24.1	24.1	33.1	34.5
Kitchen	NR BEFORE	20.0	20.0	20.0	20.0
	Door 1		SC+SE+ST	SC+SE+ST	RSTC40
	Window 1		8G+STorm	RSTC35	RSTC45
	Wall 1				
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	20.0	25.2	27.3	35.8
Bedroom #1	NR BEFORE	26.3	26.3	26.3	26.3
	Window 1 *			RSTC35	RSTC35
	Window 2			RSTC35	RSTC35
	Wall 1 *				BRIK+GYP
	Wall 2				
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	26.3	26.3	33.9	35.6
Bedroom #2	NR BEFORE	26.1	26.1	26.1	26.1
	Window 1			RSTC35	RSTC35
	Wall 1				BRIK+GYp
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	26.1	26.1	34.0	35.7
Library/Den	NR BEFORE	22.8	22.8	22.8	22.8
	Window 1		8G+STC25	RSTC35	RSTC40
	Wall 1		BRIK+GYp		BRIK+GYp
	Roof 1				VP+Absrp
	Floor 1				
	NR AFTER	22.8	27.3	32.2	36.2
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$3.96	$6.04	$13.15

* 5 dB shielding assumed.

Table 3-26
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type F

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.1	21.1	21.1	21.1
	Door 1		RSTC35	RSTC35	RSTC40
	Window 1		8G+STC25	RSTC40	RSTC45
	Window 2 *		8G+STC25	RSTC40	RSTC45
	Wall 1		BRIK+GYp		BRIK+MGA
	Wall 2 *		BRIK+GYp		BRIK+MGA
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	21.1	26.3	30.9	35.5
Dining Room	NR BEFORE	23.3	23.3	23.3	23.3
	Window 1 *		8G+STC25	RSTC35	RSTC40
	Window 2		8G+STC25	RSTC35	RSTC40
	Wall 1 *		BRIK+2GY		BRIK+2GY
	Wall 2		BRIK+GYP		BRIK+GYp
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	23.3	26.6	31.1	35.5
Kitchen	NR BEFORE	19.6	19.6	19.6	19.6
	Door 1		SC+SE+ST	RSTC40	RSTC40
	Window 1		8G+STC25	RSTC40	RSTC45
	Wall 1				
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	19.6	24.8	31.4	34.7
Bedroom #1	NR BEFORE	25.0	25.0	25.0	25.0
	Window 1 *			RSTC35	RSTC40
	Window 2			RSTC35	RSTC40
	Wall 1 *				BRIK+2GY
	Wall 2				BRIK+GYp
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	25.0	25.0	31.4	35.8
Bedroom #2	NR BEFORE	24.9	24.9	24.9	24.9
	Window 1			RSTC35	RSTC40
	Wall 1				BRIK+GYp
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	24.9	24.9	31.6	35.9
Library/Den	NR BEFORE	22.1	22.1	22.1	22.1
	Window 1		8G+STC25	RSTC35	RSTC40
	Wall 1		BRIK+2GY		BRIK+GYp
	Roof 1			SJL+GYp	SJL+A+RG
	Floor 1				
	NR AFTER	22.1	25.8	30.4	34.9
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$6.71	$9.69	$16.50

* 5 dB shielding assumed.

Table 3-27
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type G

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.4	21.4	21.4	21.4
	Door 1		SC+SE+ST	RSTC35	RSTC35
	Window 1		8G+STC25	RSTC40	RSTC40
	Window 2 *		8G+STC25	RSTC35	RSTC40
	Wall 1		BRIK+GYP	BRIK+GYp	BRIK+2GY
	Wall 2 *				BRIK+2GY
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	21.4	26.3	30.8	34.6
Dining Room	NR BEFORE	23.8	23.8	23.8	23.8
	Window 1 *		8G+STC25	RSTC35	RSTC40
	Window 2		8G+STC25	RSTC35	RSTC35
	Wall 1 *				BRIK+GYP
	Wall 2				BRIK+GYP
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	23.8	27.7	31.1	35.0
Kitchen	NR BEFORE	19.8	19.8	19.8	19.8
	Door 1		SC+SE+ST	RSTC35	RSTC40
	Window 1		8G+STC25	RSTC35	RSTC45
	Wall 1				
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	19.8	25.5	29.9	35.8
Bedroom #1	NR BEFORE	25.7	25.7	25.7	25.7
	Window 1 *			RSTC35	RSTC40
	Window 2			RSTC35	RSTC35
	Wall 1 *				BRIK+GYP
	Wall 2				BRIK+GYP
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	25.7	25.7	31.4	36.1
Bedroom #2	NR BEFORE	25.6	25.6	25.6	25.6
	Window 1			RSTC35	RSTC35
	Wall 1				BRIK+GYP
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	25.6	25.6	31.6	35.6
Library/Den	NR BEFORE	22.5	22.5	22.5	22.5
	Window 1		8G+STC25	RSTC35	RSTC40
	Wall 1				BRIK+GYp
	Roof 1				SJH+A+RG
	Floor 1				
	NR AFTER	22.5	26.6	30.4	36.1
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$3.64	$8.05	$15.20

* 5 dB shielding assumed.

Table 3-28
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type H

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	19.9	19.9	19.9	19.9
	Door 1		SC+SE+ST	RSTC35	RSTC40
	Window 1		8P+STC25	RSTC35	RSTC45
	Window 2 *		8P+STC25	RSTC35	RSTC45
	Wall 1		BRIK+GYp	BRIK+GYp	BRIK+GYp
	Wall 2 *				BRIK+GYp
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	19.9	25.1	29.5	36.1
Dining Room	NR BEFORE	21.2	21.2	21.2	21.2
	Window 1 *		8P+STC25	RSTC40	RSTC45
	Window 2		8P+STC25	RSTC35	RSTC40
	Wall 1 *		BRIK+GYp	BRIK+GYp	BRIK+GYp
	Wall 2				BRIK+GYp
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	21.2	25.9	30.5	35.2
Kitchen	NR BEFORE	19.0	19.0	19.0	19.0
	Door 1		RSTC40	RSTC35	RSTC40
	Window 1		8P+STC25	RSTC35	RSTC45
	Wall 1				
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	19.0	26.8	29.5	35.2
Bedroom #1	NR BEFORE	23.5	23.5	23.5	23.5
	Window 1 *		8P+STC25	RSTC35	RSTC40
	Window 2		8P+STC25	RSTC35	RSTC40
	Wall 1 *		BRIK+GYp		BRIK+GYp
	Wall 2		BRIK+GYp		BRIK+GYp
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	23.5	27.9	31.3	35.9
Bedroom #2	NR BEFORE	23.3	23.3	23.3	23.3
	Window 1		8P+STC25	RSTC35	RSTC40
	Wall 1		BRIK+GYp		BRIK+GYp
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	23.3	27.7	31.2	35.9
Library/Den	NR BEFORE	19.9	19.9	19.9	19.9
	Window 1		8P+STC25	RSTC40	RSTC45
	Wall 1		BRIK+GYp		
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	19.9	24.6	31.9	36.1
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$0.00	$7.85	$8.59	$14.73

* 5 dB shielding assumed.

Table 3-29
Noise Reductions, Modifications, and Cost/Dwelling Sq.Ft.,
One-Story House: Type I

Room	Building Element	Modifications by Noise Zone			
		60 – 65 dB	66 – 70 dB	71 – 75 dB	76 – 80 dB
Living Room	NR BEFORE	21.0	21.0	21.0	21.0
	Door 1		SC+SEald	RSTC35	RSTC40
	Window 1		RSTC40	RSTC45	RSTC45
	Window 2 *		RSTC40	RSTC40	RSTC45
	Wall 1			WDGY+2GY	WDGY+MGA
	Wall 2 *				WDGY+MGA
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	21.0	26.0	30.2	35.7
Dining Room	NR BEFORE	22.4	22.4	22.4	22.4
	Window 1 *		RSTC40	RSTC40	RSTC45
	Window 2		RSTC45	RSTC45	RSTC45
	Wall 1 *				WDGY+RGA
	Wall 2		WDGY+GYp	WDGY+MGA	WDGY+MGA
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	22.4	28.1	30.3	35.2
Kitchen	NR BEFORE	18.9	18.9	18.9	18.9
	Door 1	RSTC35	RSTC35	RSTC40	RSTC40
	Window 1	RSTC40	RSTC45	RSTC45	RSTC45
	Wall 1				
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	24.4	24.5	24.7	25.0
Bedroom #1	NR BEFORE	24.1	24.1	24.1	24.1
	Window 1 *			RSTC40	RSTC45
	Window 2			RSTC45	RSTC45
	Wall 1 *				WDGY+2GY
	Wall 2			WDGY+RGA	WDGY+MGA
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	24.1	24.1	30.2	35.3
Bedroom #2	NR BEFORE	24.1	24.1	24.1	24.1
	Window 1			RSTC45	RSTC45
	Wall 1			WDGY+GYp	WDGY+MGA
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	24.1	24.1	29.8	37.0
Library/Den	NR BEFORE	20.3	20.3	20.3	20.3
	Window 1		8G+STC25	RSTC45	RSTC45
	Wall 1		WDGY+GYp	WDGY+RGA	WDGY+MGA
	Roof 1				VP+Ab+GY
	Floor 1				
	NR AFTER	20.3	24.1	29.9	34.7
Cost Per Dwelling Sq.Ft.	C/D. Sq.Ft.	$1.02	$7.62	$13.40	$18.15

* 5 dB shielding assumed.