Metropolitan Council

# Builders Guide

## Mitigating Aircraft Noise in New Residential Construction

March 2006

**Metropolitan Council**
**Mears Park Centre, 230 East Fifth Street, St. Paul, Minnesota 55101**



| | |
|---|---|
| General phone | 651 602-1000 |
| Data Center | 651-602-1140 |
| TTY | 651 291-0904 |
| E-mail | *data.center@metc.state.mn.us* |
| Web site | *www.metrocouncil.org* |

Publication no. 35-06-019

Printed on recycled paper with at least 20% post-consumer waste.

On request, this publication will be made available in alternative formats to people with disabilities. Call the Metropolitan Council Data Center at 651 602-1140 or TTY 651 291-0904.

# CONTENTS

INTRODUCTION
Aircraft Noise in the Twin Cities ........ 1
Transportation Policy Plan - Land-use Compatibility Guidelines........ 1
Metropolitan Area Aircraft Noise Attenuation Act........ 2
Model Noise Ordinance........ 3

ABOUT THIS GUIDE
Purpose of the Guide ........ 4
Limitations of the Guide........ 4

HOW TO USE THIS GUIDE
Step 1. Locate Structure in Noise Zone ........ 6
Step 2. Determine If Use is Acceptable........ 7
Step 3. Determine Needed Noise Reduction ........ 8
Step 4. Establish Design Criteria........ 8
Step 5. Complete Standard Checklist ........ 9
Step 6. Determine Component STC Ratings ........ 10
Step 7. Determine Window and Patio Door Area ........ 10
Step 8. Determine Required Window STC........ 10
Step 9. Determine Adjusted STC Values ........ 15
Step 10. Select Windows to Meet STC Requirements........ 15
Step 11. Prepare Acoustical Report........ 15
Step 12. Measure Building Performance........ 15

SAMPLE DESIGN CALCULATION........ 17

APPENDIX
A. Noise Reduction Concepts ........ 18
B. References ........ 28
C. Model Noise Attenuation Ordinance........ 34
D. Application of Noise Buffer Zone ........ 39
E. Airports: Noise Policy Area Maps ........ 41

# INTRODUCTION

## Aircraft Noise in the Twin Cities

The issues and impacts of aircraft noise first started in the Twin Cities with military jet-fighter training activity at the Fort Snelling air base during the Korean Conflict. Aircraft noise has become a constant presence at Minneapolis-St. Paul International Airport (MSP) since the advent of passenger jet airline service in 1961. The noise impact grew so sever in the 1960s that a new supplemental major airport site to MSP was identified. In the 1970s, new "quieter" Stage II aircraft started replacing the very loud first-generation aircraft. A preferential runway system and other aircraft operational procedures were also implemented, helping reduce noise impacts in MSP communities.

The effects of airline deregulation began to occur at MSP in the 1980s with airport hubbing operations by both Northwest and Republic Airlines. In addition to proposed improvements from Stage III jet engine technology and airport operational changes, noise mitigation measures were also being introduced through land-use planning. In 1983, the Metropolitan Council – in cooperation with the Federal Aviation Administration (FAA), Minnesota Pollution Control Agency (MPCA), Mn/DOT Aeronautics and Metropolitan Airports Commission (MAC), affected airport communities and airport users – completed its work on aircraft noise and land-use development. The Aviation chapter of the *Metropolitan Development Guide* was amended to include ***Land-use Compatibility Guidelines for Aircraft Noise.***

During the 1990s, the Minnesota Legislature determined that MSP International Airport should be expanded. The MAC was directed to implement a 2010 MSP Development Plan and prepare a Noise Mitigation Plan. A federally defined and funded noise mitigation program was established for applying corrective land-use measures in noise impacted areas. Numerous schools, thousands of homes and residential units have been noise-insulated under the FAR Part-150 Program at MSP.

Current noise mitigation efforts have focused on updating the Part-150 Program to include year 2007 noise exposure maps. It is expected that future plan and program updates will focus on effects of runway improvements, changes in the aircraft fleet, annual aircraft activity, application of Stage IV compliant engines and other technology improvements.

## Transportation Policy Plan – Land-Use Compatibility Guidelines

The Land-use Compatibility Guidelines for Aircraft Noise are found in the Metropolitan Council's *Transportation Policy Plan* (TPP), Appendix H; they apply to MSP International Airport and all the other regional system airports. Land uses are categorized as either "New Development-Major Redevelopment" or "Infill-Reconstruction-Additions to Existing Structures."

Depending upon which aircraft noise zone the particular land use is located in, it will be identified in local community comprehensive plans as being one of the following:

- **Compatible** (COMP) – Uses that are acoustically acceptable for both indoor and outdoor activities.
- **Provisional** (PROV) – Uses that should be discouraged if at all feasible; if allowed, must meet certain structural performance standards to be acceptable according to MS473.192 (Metropolitan Area Aircraft Noise Attenuation Act). Structures built after December 1983 shall be acoustically constructed so as to achieve the interior sound levels described in Table A1 of this document. Each local governmental unit having land within the airport noise zones is responsible for implementing and enforcing the structure performance standards in its jurisdictions.
- **Conditional** (COND) – Uses that should be strongly discouraged; if allowed, must meet structural performance standards, and requires a comprehensive plan amendment for review of the project under the factors described in Table 5, Appendix H of the Council's *Transportation Policy Plan*.
- **Incompatible** (INCO) – Land uses that are not acceptable even if acoustical treatment were incorporated in the structure and outside uses restricted.

Land-use/noise compatibility is implemented through both preventive and corrective noise mitigation measures. The preventive measures apply primarily to undeveloped areas of the community where land-use designation, zoning controls, building performance standards and project development proposals for new development are reviewed by the affected governmental units and the Council for consistency with the compatibility guidelines. To assist communities with building new residential units that meet performance standards, the Council has helped pass noise legislation, developed a model noise ordinance and prepared this *Builders Guide*.

The corrective land-use measures apply primarily to developed areas of communities where mitigation of incompatible uses is necessary. Acquisition and redevelopment of property and sound insulation of sensitive land uses (such as residences, schools, churches, nursing homes, etc.) are two of the most important measures used in the MSP noise mitigation program. The funding for the corrective measures mitigation program comes from the FAA through its Part 150 Program, which is implemented at MSP by the MAC and includes funding from passenger facility charges (PFCs), and grants. Land-use compatibility measures will continue to be applied beyond the year 2005 to reflect the Metropolitan Council's *2030 Regional Development Framework* and *Transportation Policy Plan*, the Part 150 [2007] Update, and the Metropolitan Land Planning Act, which requires updated community comprehensive plans by 2008.

**Metropolitan Area Aircraft Noise Attenuation Act**

Minnesota Statutes 473.192 describes the aircraft noise attenuation act of 1987.

> Subdivision 1 - Citation - This section may be cited as the "Metropolitan Area Aircraft Noise Attenuation Act".
>
> Subdivision 2 - Definitions - For purposes of this section, "Metropolitan area" has the meaning given it in section 473.121, subdivision 2. "Aviation Policy Plan" means the plan adopted by the metropolitan council pursuant to section 473.145. "Municipality" has the meaning provided by section 462-352, subdivision 2.

Subdivision 3 - Ordinance - A municipality in the metropolitan area that, in part or in whole is within the aircraft noise zones designated in the *Transportation Policy Plan*, may adopt and enforce ordinances and controls to regulate building construction methods and materials for the purpose of attenuating aircraft noise in habitable buildings in and around the noise zone.

The ordinance or control shall not apply to remodeling or rehabilitating an existing residential building or to construction of an appurtenance to an existing residential building. An ordinance adopted by a municipality must be adequate to implement the metropolitan council's guidelines for land-use compatibility with aircraft noise. Section 16B.62 does not apply to ordinances adopted under this section.

16B.62 State Building Code; Application

Subdivision 1 - Municipal enforcement - The state building code applies statewide and supersedes the building code of any municipality.

The state building code does not apply to agricultural buildings except with respect to state inspections required or rulemaking authorized by sections 104.05, 326.244, and 216C.192, subdivision 8.

All municipalities shall adopt and enforce the state building code with respect to new construction within their respective jurisdictions.

**Model Noise Ordinance**

In 1983 a model noise ordinance governing control of aircraft noise mitigation in buildings was prepared by regional and state agencies with the assistance of acoustic consultants.

The participants in this effort determined that a performance standard, rather than detailed structural specifications, would be most appropriate. They also determined that meeting an interior level of 45dba[1] for residential land uses would be a reasonable objective.

In addition, they preferred using acoustic sound transmission class ratings (STC) rather than other single or multiple-figure ratings, since extensive STC data was available to architects and building code officials. The aim was to require a minimum amount of additional effort and cost for builders and to avoid additional laboratory testing where possible. Thus, while it was recognized that additional laboratory data would be needed, it was determined that the STC rating would still provide the simpler alternative.

The model noise attenuation ordinance that resulted from this effort is included in Appendix C. The ordinance is applied through use of a noise overlay map for the specific airport. Noise contours on the overlay map are defined using the federal noise descriptor DNL. Application of the compatibility guidelines starts at the DNL 60 noise contour for all system airports. The guidelines allow for a “buffer zone”, at the discretion of the affected community, for specific areas outside the DNL 60 noise contour.

[1] DNL, reference *Transportation Policy Plan*, Appendix H, Table 4.

# ABOUT THIS GUIDE

**Purpose of the Guide**

The *Builders Guide* has been prepared to provide builders, developers, architects and building inspectors with information to help comply with the ***Land-use Compatibility Guidelines for Aircraft Noise***. The Guide specifically addresses the noise reduction performance of structures in areas exposed to aircraft noise as defined in the *Transportation Policy Plan* of the *Metropolitan Development Guide*. The guidelines and model noise attenuation ordinance are used by the Council in its review of community comprehensive plans and plan amendments. The Guide is also intended to provide better understanding of the issues and problems encountered in complying with the guidelines and designing for exterior-to-interior noise attenuation.

The *Builders Guide* provides a satisfactory method for estimating required sound transmission class values within certain aircraft noise zones and for determining whether the design of a residence or other habitable structures (apartments, townhouses, hotels, condominiums) comply with noise reduction guidelines. It also provides STC values for a variety of building elements, including walls, roof assemblies, windows and doors.

**Limitations of the Guide**

This Guide is based upon published and unpublished data sources and manufacturer's literature and is not intended as a comprehensive handbook on acoustical techniques in construction. It is intended to permit an evaluation of building designs in an aircraft-noise environment with the aim of meeting acceptable interior noise levels. The Guide can be used for both preventive treatment (appropriate new construction) and for some corrective treatment.

The Metropolitan Council does not guarantee that any specific level of noise reduction will be achieved through the application of this *Builders Guide*. Too many factors, ranging from the aircraft noise spectrum and details of building design, to the estimated STC values presented in this Guide, are subject to variation and error. The procedures in this Guide assume that good building practices are followed. It should be noted that application of the procedures in this Guide does not address the problem of low-frequency noise and associated vibrations within a structure caused by this noise. Procedures and guidelines for control of low-frequency noise within structures are being evaluated by the FAA.

This Guide provides the level of detail needed for an acoustical evaluation in Noise Zones 1 through 4 at the region's system airports. The regional airport system is shown in Figure 1. No attempt has been made in this Guide to estimate the cost of meeting noise reduction guidelines since, for many contemporary designs, no additional costs will be incurred. Design requirements of the State Energy Code may be sufficient to meet sound attenuation guidelines in Noise Zone 4; however, differences do exist between acoustical and thermal evaluation; these are discussed in Appendix A.

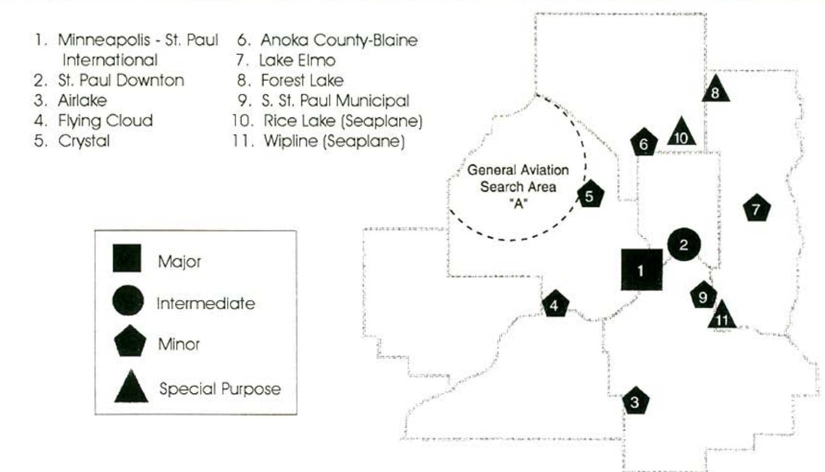
The listing of STC data contained in the Guide is not intended to be complete but is based upon the type of construction commonly found in a review of homes proposed in Noise

Zone 4 at MSP International Airport. It also contains additional information collected from various sources and manufacturers of building products. The STC values are limited and subject to revision.

The use of actual test data for building components is strongly recommended and may be explicitly required in some communities. This *Builders Guide* is not intended to remove the responsibility of the architect, engineer or builder to obtain and use actually measured STC values when required.

Figure 1

**Regional Airport System**



# HOW TO USE THIS GUIDE

The following step-by-step process will help the user of this Guide to achieve appropriate structural noise reduction. A sample calculation following the approach described here is included on page 17.

**Step 1. Locate Structure in Noise Zone**

Check with the affected community to see if the building site is located within an aircraft noise zone or one-mile buffer zone. If the structure is located within Noise Zones 1 or 2, an analysis, by a recognized acoustical specialist, more detailed than that provided by this Guide is recommended. If the structure is located in Noise Zones 3 or 4, this Guide may be used.

Application of noise control efforts in a noise "buffer zone" at MSP or at the reliever airports is done at the discretion of the affected community (see Appendix D). Check to see if the community has adopted use of the buffer zone in its land-use plan or local ordinances.

Maps of the noise contours are included in the *Transportation Policy Plan*, Appendix H, which can be accessed on the Council's website (metrocouncil.org). Metropolitan area communities currently included within aircraft noise zones are:

**Airlake Airport**
- City of Lakeville
- City of Farmington
- Eureka Township

**Anoka Co.-Blaine Airport**
- City of Blaine

**Crystal Airport**
- City of Crystal
- City of Brooklyn Park

**Flying Cloud Airport**
- City of Eden Prairie

**Lake Elmo Airport**
- City of Lake Elmo
- West Lakeland Township

**MSP International Airport**
- City of Minneapolis
- City of Richfield
- City of Bloomington
- City of St. Paul
- City of Eagan
- City of Mendota Heights
- City of Burnsville

**St. Paul Downtown Airport**
- City of Saint Paul

**South St. Paul Airport**
- City of So. St. Paul
- City of Inver Grove Heights

## Step 2. Determine If Use Is Acceptable

If the building site lies within an aircraft noise zone, as determined in Step 1, what do regional compatibility guidelines say about acceptable uses? Table 1 shows acceptable land uses in the particular noise zones.

**Table 1**
**Land-use Compatibility Guidelines for Aircraft Noise**

| | **Noise Exposure Zones** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Type of Development** | **New Development or Major Redevelopment** | | | | | **Infill - Reconstruction or Additions to Existing Structures** | | | | |
| Land-use Category | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Buffer Zone[1] | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Buffer Zone |
| | DNL 75+ | DNL 74-70 | DNL 69-65 | DNL 64-60 | | DNL 75+ | DNL 74-70 | DNL 69-65 | DNL 64-60 | |
| **Residential** | | | | | | | | | | |
| Single/Multiplex, with individual entrance | INCO[2] | INCO | INCO | INCO | COND | COND | COND | COND | COND | PROV |
| Multiplex/Apartment, with shared entrance | INCO | INCO | COND | PROV | COMP | COND | COND | PROV | PROV | COMP |
| Mobile Home | INCO | INCO | INCO | COND | PROV | COND | COND | COND | COND | PROV |
| **Educational, Medical, Schools, Churches, Hospitals, & Nursing Homes** | INCO | INCO | INCO | COND | PROV | COND | COND | COND | PROV | COMP |
| **Cultural, Entertainment, & Recreation** | | | | | | | | | | |
| Indoor | COND[3] | COND | COND | PROV | COMP | COND | COND | COND | PROV | COMP |
| Outdoor | COND | COND | COND | COND | PROV | COND | COND | COND | COMP | COMP |
| **Office, Commercial, Retail** | COND | PROV | PROV | COMP | COMP | COND | PROV | PROV | COMP | COMP |
| **Services** | | | | | | | | | | |
| Transportation - Passenger Facilities | COND | PROV | PROV | COMP | COMP | COND | PROV | PROV | COMP | COMP |
| Transient Lodging | INCO | COND | PROV | PROV | COMP | COND | COND | PROV | PROV | COMP |
| Other Medical, Health, and Education | COND | PROV | PROV | COMP | COMP | COND | PROV | PROV | COMP | COMP |
| Other Services | COND | PROV | PROV | COMP | COMP | COND | PROV | PROV | COMP | COMP |
| **Industrial, Communication, & Utilities** | PROV[4] | COMP | COMP | COMP | COMP | PROV | COMP | COMP | COMP | COMP |
| **Agriculture, Land/Water Area, & Resource Extraction** | COMP[5] | COMP | COMP | COMP | COMP | COMP | COMP | COMP | COMP | COMP |

Note: The *Transportation Policy Plan* adopted in 2004 includes an Appendix H that addresses the *Land-use Compatibility Guidelines for Aircraft Noise*. The purpose of the buffer zone is to provide additional protection for noise sensitive uses within the context of preventive land-use measures, allow for contour expansion/contraction over time, and provide flexibility in using other tools in support of noise efforts (e.g., a TIF district), that may be partially outside the then “current” noise contours. Use of a buffer zone is encouraged, but it is a voluntary effort; implementation is at the discretion of the affected community. Application of the “buffer zone” in local comprehensive plans is discussed in Appendix D.

[1] Buffer Zone (see definitions in Appendix D)
[2] INCO means "Incompatible"
[3] COND means "Conditional"
[4] PROV means "Provisional"
[5] COMP means "Compatible"

**Step 3. Determine Needed Noise Reduction**

If the use is acceptable, what is the required noise level reduction? Table 2 shows the required noise level reduction for each acceptable land use.

**Table 2**
**Land Use Compatibility Guidelines and Noise Reduction requirements for Aircraft Noise**

| | **Noise Exposure Level (dBA)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Type of Development** | **New Development or Major Redevelopment** | | | | | **Infill - Reconstruction or Additions to Existing Structures** | | | | |
| **Land Use Category** | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Buffer Zone | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Buffer Zone |
| | DNL 75+ | DNL 74-70 | DNL 69-65 | DNL 64-60 | | DNL 75+ | DNL 74-70 | DNL 69-65 | DNL 64-60 | |
| **Residential** | | | | | | | | | | |
| Single/Multiplex, with individual entrance | INCO | INCO | INCO | INCO | 19 | 30+ | 29 | 24 | 19 | 19 |
| Multiplex/Apartment, with shared entrance | INCO | INCO | 24 | 19 | COMP | 30+ | 29 | 24 | 19 | COMP |
| Mobile Home | INCO | INCO | INCO | 19 | 19 | 30+ | 29 | 24 | 19 | 19 |
| **Educational, Medical, Schools, Churches, Hospitals, & Nursing Homes** | INCO | INCO | INCO | 19 | 19 | 30+ | 29 | 24 | 19 | COMP |
| **Cultural, Entertainment, & Recreation** | | | | | | | | | | |
| Indoor | 25+ | 29 | 24 | 19 | COMP | 30+ | 29 | 19 | 19 | COMP |
| Outdoor | 30+ | 29 | 24 | 19 | 19 | 30+ | 29 | 19 | COMP | COMP |
| **Office, Commercial, Retail** | 30+ | 29 | 24 | COMP | COMP | 30+ | 29 | 19 | COMP | COMP |
| **Services** | | | | | | | | | | |
| Transportation - Passenger Facilities | 30+ | 29 | 24 | COMP | COMP | 30+ | 29 | 24 | COMP | COMP |
| Transient Lodging | INCO | 29 | 24 | 19 | COMP | 30+ | 29 | 24 | 19 | COMP |
| Other Medical, Health & Education | 30+ | 29 | 24 | COMP | COMP | 30+ | 29 | 24 | COMP | COMP |
| Other Services | 30+ | 29 | 24 | COMP | COMP | 30+ | 29 | 24 | COMP | COMP |
| Industrial, Communication, & Utilities | 30+ | COMP | COMP | COMP | COMP | 30+ | COMP | COMP | COMP | COMP |
| Agriculture, Land/Water Areas, and Resource Extraction | COMP | COMP | COMP | COMP | COMP | COMP | COMP | COMP | COMP | COMP |

**Step 4. Establish Design Criteria**

It is recommended that the principles listed below be incorporated into the building design in its earliest phases to minimize exterior-to-interior sound transmission. Most of these principles are also consistent with the Minnesota Energy Code. Alternate design features may be accommodated but may require a more extensive acoustical evaluation.

- Avoid large areas of glass unless appropriate STC can be provided.
- Use solid-core exterior doors (in combination with storm doors) where possible.
- Use patio (glass) doors sparingly.
- Do not use large wooden frame casement windows that cannot accommodate the weight of heavier glazing.
- Use skylights sparingly (STC rated if possible).
- Avoid roof-ceiling structures without insulated attics.
- Specify caulking and sealing off all through-the-wall penetrations.
- When using sound channels on interior skin, avoid bypassing channels by attaching shelving and appliances directly to studs.

**Step 5. Complete Standard Checklist**

What type of acoustical information does the city require? A checklist of information needed for an acoustical evaluation should be completed and submitted to the local building inspector (check boxes below).

| √ | **Table 3**<br>**Standard Checklist of Required Acoustical Information** |
|---|---|
| | 1. Name, address and telephone number of building plan submitter, architect, or other contact person for questions or clarifications of the plans and information submitted. |
| | 2. Location of the site on the Noise Policy Area Map (including noise buffer zone when applied by community). |
| | 3. Set of the plans and specifications with the following information: |
| | a. Floor plans and evaluations. |
| | b. Information on exterior envelope of the building: |
| | Exterior wall systems, including materials, elevations, sections, thermal or acoustical insulation used, R-values and STC values where available (or estimated). |
| | Roof-ceiling systems, including materials, elevations, sections, thermal or acoustical insulation used, R-value and STC values where available (or estimated). |
| | Window specifications and schedule, product(s) upon which door specifications were based, R-values and STC values where available (or estimated). |
| | Exterior door specifications and schedule, product(s) upon which door specifications were based, R-values and STC values where available (or estimated). |
| | c. Basement and floor-ceiling details if basement is vented or has windows, doors, or other major penetrations through the exterior walls. |
| | d. Attic-space venting information on thermal or acoustic insulation not provided elsewhere. |
| | e. Heating-ventilating system (and fireplace), especially details of any penetration through exterior walls or roof. |
| | f. Specifications for airtight seals on windows and doors. |
| | g. Specifications for caulking and treatment of penetrations through exterior walls. |
| | h. Room finish schedules, especially if carpet or other acoustically absorbent materials are to be installed. |
| | i. Any other information that may be helpful in estimating the overall noise reduction of the exterior surface of the structure. |
| | 4. A complete set of plans and specifications can be submitted in lieu of information outlined above in Number 3 if all relevant information is included. |

**Step 6. Determine Component STC Ratings**

Estimate STC ratings from the following tables for roof-ceiling, wall, window construction, glazing, and door assemblies. The STC rating is a single-number rating based upon a standard laboratory procedure. The basis for this rating is described in Appendix A. STC ratings will be used in Steps 8 through 10 to determine whether the proposed windows are satisfactory. Roof-ceiling construction can generally be broken into two classes: single-joist systems and attic-space systems. The use of attic-space systems is generally required in Minnesota because of the climate and the Minnesota Energy Code. However, information on both systems is included here. Venting of the attic space as required by the building code will reduce the acoustical effectiveness of construction as noted in Table 4. **A roof-ceiling STC value of at least 40 STC is assumed in the design charts used in this guide. A roof-ceiling with STC lower than 40 should not be used in any of the aircraft noise zones.**

**Step 7. Determine Window and Patio Door Area**

Calculate the percentage of total exterior wall area (in square feet) represented by windows and patio doors (glazed), or take this information from the standard calculation needed to meet the state energy code. These percentages and the STC value of the wall will be used in Step 8 to determine the required window STC. If a particular room has a window area greater than 30%, this room should be analyzed as a separate entity separate from the overall exterior building facade (see Step 8). If there are any skylights, their area should be added to the wall plus window area and included in the calculation.

**Step 8. Determine Required Window STC**

Based upon the percent of window area and patio doors determined in Step 7, use Figure 2 through Figure 4 to determine the window STC required to meet the Land-use Compatibility Guidelines for particular noise zones. These figures are based upon a needed sound reduction of 20dBA.

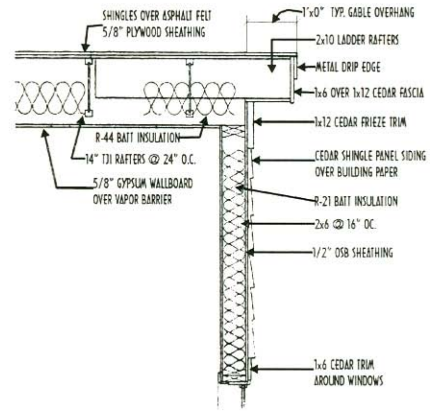
Figure 2. Window STC Requirements - Wall @ 40 STC
Figure 3. Window STC Requirements - Wall @ 45 STC
Figure 4. Window STC Requirements - Wall @ 50 STC

These figures assume a door STC of at least 26 (with no more than 1% of exterior wall area) and a patio door with STC of 28. Patio doors with STC of less than 28 are not recommended. These figures are applicable to Noise Zone 4. **For sites located in Noise Zone 3, add 5 STC to the window STC value determined from these figures.** The wall STC determined in Step 6 should be used to select the correct graph to be used. If wall, door or patio door STC values are well outside those used in the figures, then outside assistance may be required. Use the following figures for determining the required window STC ratings for Noise Zone 4 (note that these figures assume the following typical STC values: Door STC 26, Patio Door STC 28, Roof-Ceiling STC 40 or greater).

Table 4

## Ceiling Material and STC Rating (Typical Sections)

| Roof Material | Single-Joist Systems: 1/2" Gypsum Board | Single-Joist Systems: Exposed Joist |
|---|---|---|
| Wood shingles | 45 | 34 |
| Composition shingles | 49 | 40 |
| Clay or concrete tiles | 57 | 45 |
| Build-up roofing | 49 | 37 |
| 1/3" wood-sheet metal | -- | 36 |




| Roof Material | Attic-Space Systems: 1/2" Gypsum Board | Attic-Space Systems: Exposed Joist |
|---|---|---|
| Wood shingles | 41 | 43 |
| Composition shingles | 42 | 44 |
| Clay or concrete tiles | 43 | 45 |
| Build-up roofing | 41 | 43 |
| 1/3" wood-sheet metal | 41 | 43 |

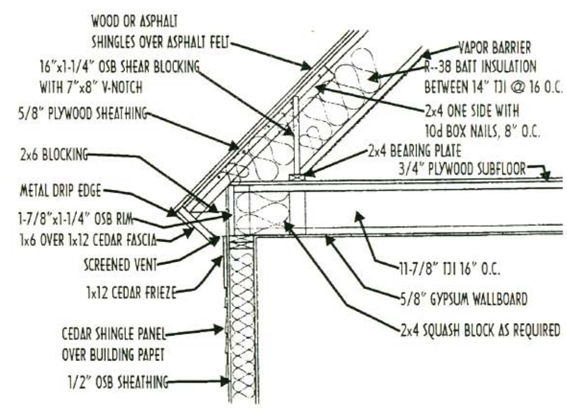


Figure 2

**Window STC Requirements - Wall @ 40 STC**

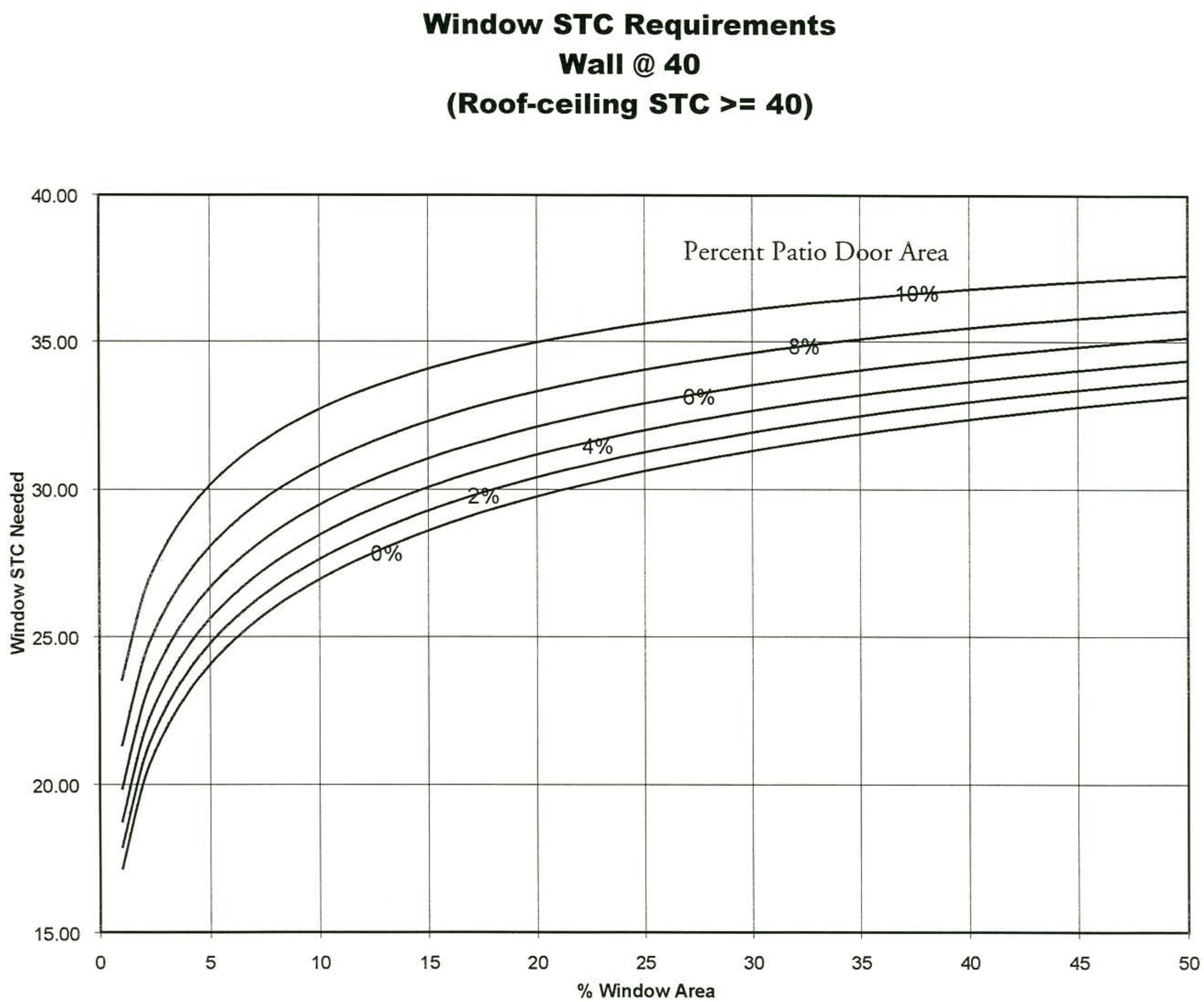


Figure 3

**Window STC Requirements - Wall @ 45 STC**

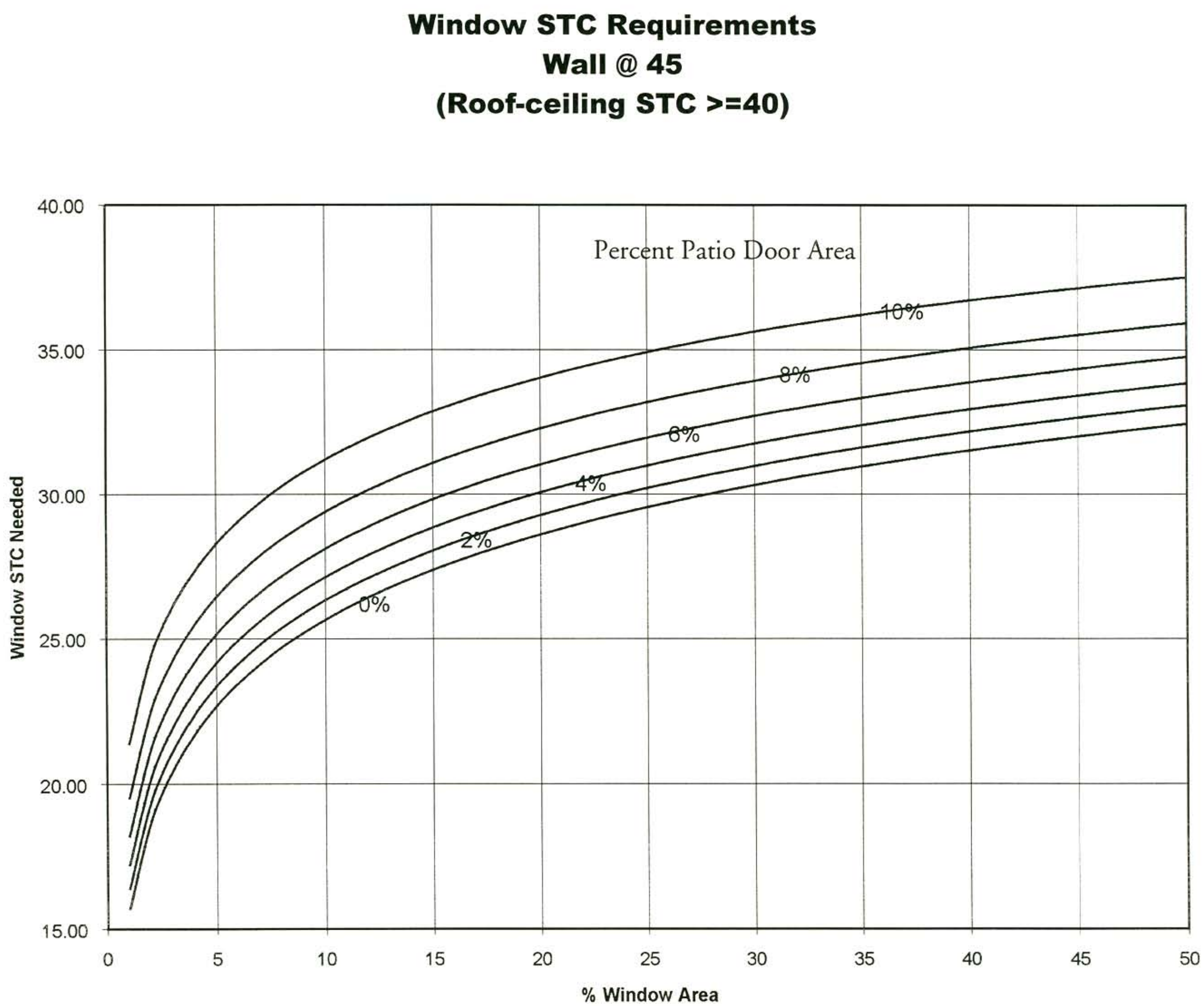
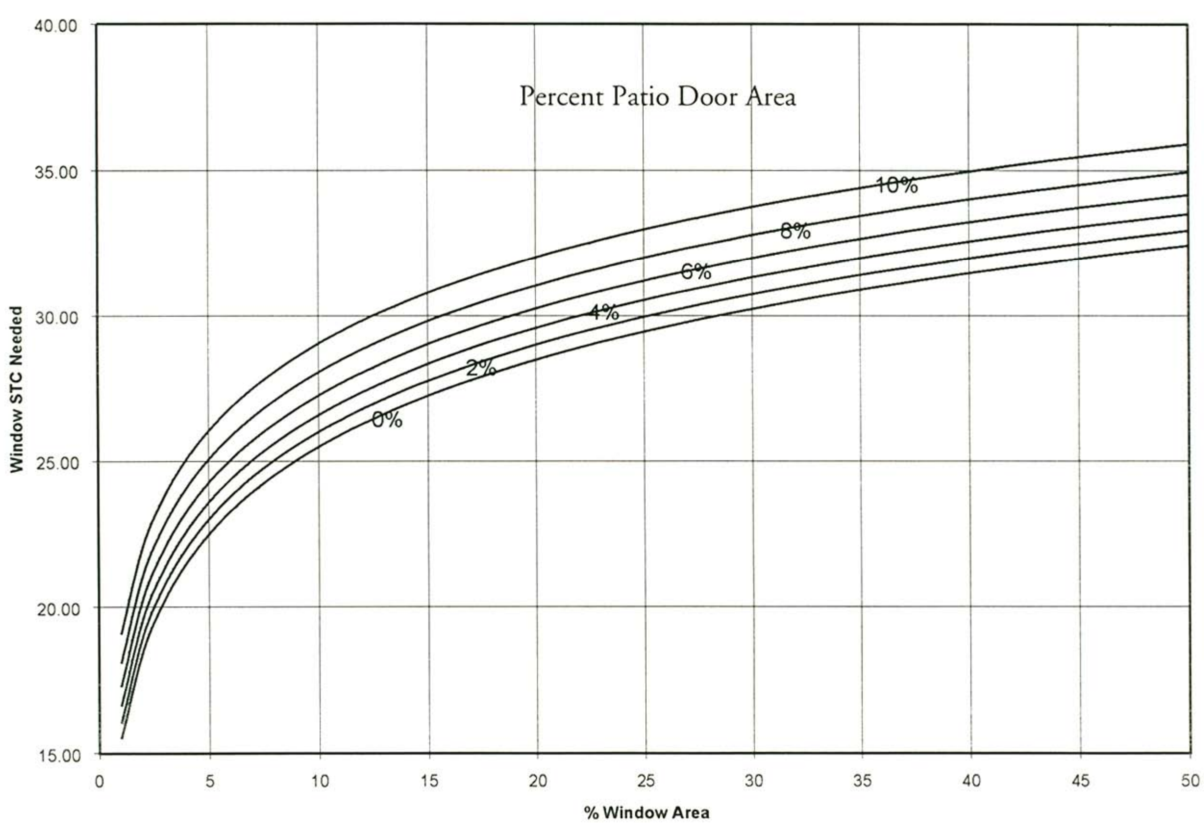


Figure 4

## Window STC Requirements - Wall @ 50 STC

**Window STC Requirements**
**Wall @ 50**
**(Roof-ceiling STC >=40)**



**Step 9. Determine Adjusted STC Values**

The following corrections should be made to the basic window STC ratings determined from Figures 2 through 4.

- When there are more than two exterior walls in a room +3 STC
- Rooms without carpeting or soft furniture +2 STC
- Resilient mounting of interior gypsum wall -1 STC
- If entry door rating is less than 26 STC +1 STC
- If patio door rating is less than 23 STC and area is over 5 percent +2 STC

**Step 10. Select Windows to Meet STC Requirement**

Compare the STC ratings of the proposed windows as determined in Step 6 and compare these with the regional adjusted value determined in Step 9. If the proposed STC value is insufficient to meet the requirement, then one or a combination of the following alternatives should be considered:

1) Select a window (Step 6) with the required STC value.
2) Reduce window area.
3) Use walls or patio doors with higher STC values.

**Step 11. Prepare Acoustical Report**

If the design can be shown to meet the noise level reduction required, the completed acoustical report should then be submitted to the local building inspector. An example is shown in Table 5.

**Step 12. Measure Building Performance**

Acoustic testing may be required under the city ordinance if the plans are changed following the acoustical review and no subsequent substantiation of the building performance is provided to the building inspector.

Should testing of the finished structure be necessary, the ASTM (American Society for Testing Materials) E 966-04 standard for measuring exterior-interior noise reduction should be followed. This test is described in the *Annual Book of ASTM Standards* (see references).

Use of this Guide does not guarantee that a specific noise level reduction can be met.

**Table 5**
**Sample Plan Review for Compliance with Aircraft Noise Ordinance**

| **Submitter:** | **Noise Impact Area:** |
|---|---|
| *John Doe Construction, Inc.*<br>*0000 Avenue Z*<br>*Minneapolis, MN 55000*<br><br>*Telephone*<br>*(000) 000-0000* | *Airport - MSP International*<br>*Noise Zone – 4*<br><br>*New Infill Residence is a "COND" use in Noise Zone 4.* |

**Plan Reviewed**:

*Single-family home for John & Susan Doe*

**Information Submitted**:

*Annotated architectural drawings including:*

*Windows: Acme clad casements*
*Swinging Patio Doors: Acme clad*
*Entry Doors: Acme Insulated metal*
*Skylights: Acme fixed skylights*

**Compliance with STC Requirements:**

*Average window/wall area for exterior wall: 14%*

*With this window/wall area ratio and STC 45 walls, windows with an STC 29 can be used to meet the noise reduction requirements.*

**Summary:**

*Other measures including duct bends and caulking are being taken to ensure minimum transmission of noise through the exterior building shell so that the construction should meet the intent of the noise ordinance and the Metropolitan Council compatibility guidelines.*

*Therefore, the materials and construction as proposed should meet the requirements of the [City] aircraft noise ordinance.*

**Review Completed** [Date] **By:**

*Name, address and telephone number of person completing review.*

**Compliance with Procedures to Ensure Adequate Noise Attenuation:**

Exterior wall construction:
*Cedar siding*
*15/32" sheathing*
*Tyvek wrap*
*2x6 studs 16" o.c.*
*6" batt insulation with 1/2" gypsum board*

Roof Construction:
*Peaked roof with manufactured trusses 24" o.c.*
*Roof vents*
*270# shingles*
*15# felt*
*1/2" sheathing*
*Blown Insulation*
*5/8" gypsum board*

Mechanical Ventilation System:
*4-ton central air conditioning unit*

Window, Door Frame, Perimeter and Other Seals:
*All window and door openings are to be caulked With butyl-based caulk.*

Fireplace Chimney Cap:
*Built-in flue damper, chimney cap, glass enclosed.*

Ventilation Duct Exterior Wall Penetrations:
*All exterior ducts will have bends as required by The ordinance.*

Door and Window Construction:
*Windows: Acme clad casement, 1" insulating (29 STC) or high -performance glass.*

Swinging Patio Doors:
*Acme clad 3/4" insulating (28 STC) or high -performance glass (30 STC).*

Entry Doors:
*Acme Insulating metal (26 STC)*

Skylights: *(STC not provided)*

Other Exterior Wall Penetrations:
*Sill sealer between plates and blocks.*

# SAMPLE DESIGN CALCULATION

**Step 1. Locate Structure:** Using the airport noise maps in Appendix E, determine the noise zone in which the structure is located. Assume in this example that a new single-family residential structure is proposed as infill in aircraft Noise Zone 4 at MSP International Airport.

**Step 2. Determine If Use Is Acceptable:** From Table 1 the compatibility of the particular proposed structure can be determined. For this single-family residential example the use is "conditional" – that is, subject to the requirements of the local noise ordinance and specific stipulations (review criteria) contained in the land-use compatibility guidelines.

**Step 3. Determine Needed Noise Reduction:** Table 2 then indicates the needed noise level reduction for the structure. In this case, with a structure in Noise Zone 4, the needed noise reduction is almost 20dBA. Therefore, Figure 2 through Figure 4 can be used directly. If a 25dBA reduction were needed (Zone 3), 5dBA would have to be added to the required window STC determined from these figures.

**Step 4. Establish Design Details:** It is assumed that the house design takes into account the basic good acoustical practices listed on page 8.

**Step 5. Complete Standard Checklist:** A standard checklist can then be completed as shown on page 9.

**Step 6. Determine Component STC Ratings:** It is assumed for this example that the roof-ceiling system has an STC of 41. The wall system is assumed to have an STC of 45. The proposed windows have an STC of 27.

**Step 7. Determine Window and Patio Door Area:** The given design indicates a window area of 12%, a patio door area of 2%, a door area of 1% and a wall area of 85%.

**Step 8. Determine Required Window STC:** Using Figure 3 (wall of 45 STC) the required window STC is 27. For this design, the proposed window is satisfactory and the structure meets the guidelines.

**Step 9. Determine Adjusted Window STC:** In this case, no adjustments are needed. If, for example, a patio door area of 6% were used, an STC of 29 would be needed. This could be achieved by either picking an improved window or by reducing the window area to just over 8%.

**Step 10. Select Windows to Meet STC Requirement:** If a patio door area of 6% is assumed, a 29 STC window would have to be used. A variety of windows are available with this STC rating as can be seen in Appendix E. A high-quality casement window with high-performance insulating glazing should provide this type of an STC rating.

**Step 11. Prepare Acoustical Report:** An acoustical report such as that shown in Table 5 should then be completed.

**Step 12. Measure Building Performance:** Unless changes are made in the plans, no supplementary analysis is submitted to the building inspector for approval, the building inspector may, under the terms of the ordinance, require that actual sound transmission tests be made of the completed structure.

# APPENDIX A
# NOISE REDUCTION CONCEPTS

Noise is commonly defined as "unwanted sound". Aircraft noise is unwanted sound emanating from aircraft operations.

***DEFINITIONS***

Decibel: This is a measure of relative sound pressure in the atmosphere referenced to an arbitrary standard pressure. Decibel is abbreviated "dB."

Frequency Spectrum: Sound energy occurs at a wide range of frequencies, with those normally perceptible by the human ear between 20 Hz (cycles per second) and 20,000 Hz. A separate sound level is associated with each of these separate frequencies. Combining these into "weighted" decibel scales provides a measure of overall sound pressure.

A-Weighted Decibel: This is a weighted sum of spectral sound energy in which each frequency is given a weight similar to that perceived by the human ear. Thus, the A-weighted decibel (or dBA) is commonly used as the measure of community noise impact.

Addition of Decibels: Decibels are added on the basis of logarithmic ratios. Thus, the addition of two equal sound levels yields a level 3 decibels higher than each individual sound level. A sound level, which is 10 decibels lower than another, contributes nothing to the overall sound level.

Noise Level Reduction (NLR): This term expresses the effectiveness of a structure in reducing exterior sound level. Generally speaking, it is the difference between noise outside of a building and noise inside a building during the same time period.

***EFFECT OF NOISE***

Noise can have a wide range of impacts on persons exposed to levels that are not wanted or anticipated. The three primary effects normally used to establish acceptable interior noise levels are:

- sleep interference
- sleep awakening
- annoyance

The acceptable interior levels established by the Metropolitan Council (see Table 1) are intended to provide reasonable protection against these effects.

***THE SOUND SPECTRUM***

Room absorption differs from sound transmission loss in that it dissipates rather than stops acoustical energy. A material that is excellent for sound-transmission loss (e.g., steel door) is a very poor absorber. A material that is an excellent absorber (e.g., acoustical fiberglass) has a very low sound transmission loss. The effect of absorption in a receiving room is that it increases the effective sound-transmission loss of a partition because the energy passing through the partition is partly absorbed. For example, the same wall located in a living room (with greater than average absorption) and a kitchen (with less than average absorption) could have a difference in effective sound transmission loss of a s much as 4dB.

***DIFFERENCE BETWEEN ACOUSTICAL & THERMAL INSULATION***

The Transmission of acoustical and thermal energy does not follow the same physical principals. Acoustical energy flow is more easily retarded by heavy and rigid materials, while thermal energy flow is more easily retarded by materials with low thermal conductivity. An example of a good acoustical barrier but a poor thermal barrier is a solid steel door. While the door is massive and hence minimizes sound penetration, it has a high thermal conductivity and hence does not minimize heat transmission. An example of a good thermal barrier but a poor acoustical barrier is a lightweight but thick thermal insulating panel. This barrier minimizes heat transfer but is generally a poor sound insulation.

Both sound and energy can be transmitted through an open space in the wall, such as a poor seal around a window. Such a crack can increase heat flow through the wall, and can reduce the STC value of the window by up to 5 or more STC units. For this reason, sealing and caulking through the wall penetrations is critical for good noise control.

Thermal energy is diffused through a barrier at a rate determined by the thermal conductivity of the material. This thermal conductivity is strongly affected by the physical and chemical structure of the material. Acoustical energy is transmitted through a barrier in the form of wave or vibration energy. This transmission depends upon the physical and mechanical properties of the material, as well as the structural system itself, which can vibrate in response to sound impinging on the surface. Thermal transmission through a wall can be analyzed separately for each component of the wall; acoustical energy cannot. The method used in this guide is based upon the flow of acoustical energy through a wall/window system and takes into account this difference between thermal and acoustical transmission.

While an adequate thermal treatment may acoustically insulate a residence in Noise Zone 4 (where a 25dBA NLR is required), it is more likely not to do so in the higher noise zones, where special attention should be paid to the nature of acoustical energy transmission.

***CONCEPT OF SOUND TRANSMISSION CLASS (STC)***

The purpose of single-number acoustical ratings, such as the STC, is to provide a quick and simple method of building-element selection to meet the desired acoustical requirements. The STC was originally established to provide some measure of speech privacy between rooms and is hence based primarily upon frequencies important in human speech. However, by analyzing the transmission loss for each frequency and comparing this with an aircraft noise spectrum it is possible to establish the STC value needed to meet a given A-weighted decibel reduction.

Sound transmission class is defined under the American Society for Testing Materials Standard E413-87. STC is derived from the use of a standard curve that is fitted to the observed laboratory data. STC values are available primarily for interior partitions and acoustically rated windows. These are provided by the manufactures of wall components and partitions or are found in standard reference manuals. For many common building elements, laboratory ratings are not yet available. It may be necessary to contact window and door manufactures or their representatives directly if published test data are not readily available. STC estimates for custom-built windows must be determined by comparing these windows with other manufactured ones for which such data are available.

Detailed test data are generally available for acoustic-rated windows, which are specially constructed to minimize sound transmission. These windows are generally constructed of metal because of the need to build in the sound and vibration isolation details that are essential to achieving a high STC rating. Non-acoustic rated windows, for which STC data are not generally available, are commonly proposed for use in residential construction. For Noise Zones 3 and 4, the careful use of non-acoustical-rated windows may be sufficient to meet the Council guidelines. However, as the need for greater window attenuation increases, it may be necessary to employ only acoustic-rated windows to meet the guidelines. Use of acoustical storm windows and doors can also provide relatively high STC ratings in conjunction with high quality doors and windows.

### *OTHER SINGLE-NUMBER TRANSMISSION RATINGS*

When the first version of this *Builders Guide* was issued in 1980, the Exterior Wall Rating (EWR) was the primary single-number rating that had been developed specifically to address the problem of exterior-interior noise transmission. The EWR standard curve is similar to that of STC except that the lower frequencies, normally associated with transportation noise, are given more emphasis. Since a wide variety of test data on exterior walls were available in terms of EWR, these were converted to approximate STC values that have been used in this Guide. More recently, the OITC (Outdoor-Indoor Transmission Class) is another single-number rating that has been developed (ASTM E1332-90). This rating employs a reference level and is intended primarily as a rank ordering device, with actual source spectra recommended to determine actual noise reduction. Another single-number rating that has been recently developed is the Aircraft Noise Level Reduction (ANLR) which uses a reference level more similar to noise from a departing aircraft. The ANLR and OITC generally differ by 1dB to 2dB for typical exterior walls.

### *REASONS FOR EMPLOYING STC VALUES IN THIS GUIDE*

In the development of the Model Ordinance for aircraft noise, the decision was made to use STC rather than other single or multiple-figure ratings because extensive STC data are available to architects and building code officials. The STC rating was deemed to require the minimum amount of additional effort and cost for builders and that additional laboratory testing should be avoided where possible. Thus, it was decided that STC ratings would provide the simplest alternative.

### *EXTERIOR BUILDING SHELL NOISE REDUCTION*

For purposes of this Guide, the overall exterior building shell has been used as the primary determinant of structural elements, primarily windows and doors. Since total exterior surface area is required for calculation of thermal efficiency and compliance with the Minnesota Energy Code, this information is normally readily available to architects and builders. However, when a large amount of glass is used for a given room, an evaluation of the overall exterior building shell no longer provides an accurate estimate of the level of noise that can be experienced in this room. Therefore, for rooms with greater than 30% or greater window or glass area, the procedures of this Guide should be applied to that room alone. If the room has its own exterior roof, that roof-ceiling combination should have a rating of at least 40 STC.

### *OVERALL NOISE REDUCTION LEVEL REQUIREMENTS]*

The overall noise reduction level (NRL) required within a given noise zone can be determined by subtracting the desired level (45dBA) from the highest noise level within that contour. For example, in Noise Zone 4 (60 to 64dBA), the required reduction is calculated as 64 – 45 = 19dBA. The structure performance standards adopted by the Council are shown in Table A1.

| Table A1<br>**Structure Performance Standards**[1] | |
|---|---|
| **Land Use** | **Typical Interior[2] Sound Level** |
| Residential | 45 dBA |
| Educational/Medical/Churches, etc. | 45 dBA[3] |
| Cultural/Entertainment/Recreational | 50 dBA |
| Office/Commercial/Retail | 50 dBA |
| Services | 50 dBA |
| Industrial/Communication/Utility | 60 dBA |
| Agricultural Land/Water Area/Resource Extraction | 60 dBA |

[1] These performance standards do not apply to buildings, accessory buildings, or portions of buildings that are not normally occupied by people.
[2] The noise description used to delineate the appropriate noise policy zone is an annualized Ldn.
[3] Special attention is required for certain noise sensitive uses, such as concert halls.

Each local government that has land within an airport's noise zones will be responsible for implementing and enforcing these performance standards within its jurisdictions. The Council will review the adequacy of these mechanisms as part of its review of amendments to each community's comprehensive plan. This Guide has been developed to assist in "preventive" treatment; "corrective" treatment can be more complex, but could be addressed with this Guide provided that appropriate simplifying assumptions can be made.

***EVALUATION OF COMPOSITE EXTERIOR SURFACES***

Since a building is made up of a number of different elements, such as walls, windows, doors, the "composite" noise reduction of this combination must be determined. This evaluation is made in terms of energy passing through the wall. The energy is then summed and converted back into the noise reduction level in dBA. (See Figure A1 for evaluating a wall with two separate elements, each with different transmission loss values.)

***OTHER WEIGHTING FACTORS CONSIDERED***

The NRL required by the Noise Compatibility Guidelines is specified in dBA, while structural elements are specified in STC. Therefore, a number of factors must be considered to convert the collection of individual building element STC values to an overall building shell NRL that is specified in terms of dBA. These factors are:

1. Noise Source Spectrum: Aircraft
   While actual spectra for takeoff and landing vary with the type of aircraft, operating conditions and meteorology, the aircraft noise spectrum used by Tocci et al. (see references) is an acceptable reference spectrum for purposes of this Guide. The use of an aircraft spectrum to estimate sound transmission through a wall is especially important since the low frequency components are not adequately addressed by the STC methodology.

2. Composite Wall STC Value
   The standard procedures for determining the effective transmission value of a composite wall has been followed here (see Figure A1).

3. Field Installation Loss
   It is common practice to assume that the laboratory-measured value of a partition can be 5dB lower when it is installed in the field.

4. Average Room Absorption/Exterior Surface Area
   The sound pressure level in the receiving (interior) room can be estimated from the following expression: NRL = (TL - 10logS+10logA)-6 Where: NRL = Noise Reduction Level (dBA), where:
   TL = Transmission Loss (measured dBA), S = Wall area (square feet)
   A = Total room absorption (sabines)

   With an exterior wall area of 100 square feet, the effective laboratory-rated transmission loss (or STC here) could be as much as 10 dBA lower than the laboratory value if the receiving room is very hard (reflective) acoustically compared with a very absorptive room. For purposes of standardization, a room with an average absorption of 0.6 was used, making the difference between the Noise reduction level and Wall transmission Loss less than 1 dBA.

5. Number of Walls Exposed
   As noted in the Wyle study for the FHWA (Davy and Skala, 1997), the number of walls can have a significant impact on the effectiveness of any exterior wall. While three or four exterior surfaces could exist in the most unfavorable situation, a single wall was chosen for the standard case.

6. Angle of Incidence
   The angles at which sound from aircraft flights might be expected to hit exterior surfaces can be estimated for particular flight paths. This could raise the effective transmission loss for the wall or its components by as mush as 5 dBA, which is the approximate difference between random and field incidence (Beranek, 1988). However, since the model ordinance is intended to apply to a wide range of locations and structural orientations, a random angle of incidence was selected for determining STC requirements.

***AIRPORT NOISE ZONE MAPS***

Individual noise zone maps for the regional system airports are depicted in Appendix E of the Council's *Transportation Policy Plan*. The noise zones reflect the latest long-term comprehensive plans approved for the airport or approved environmental analysis that reflects the airport plan. Noise zones are defined using the federal noise descriptor for day/night noise levels (expressed as DNL).

Note: A number of the airport development plans and associated noise impact maps are being updated during 2006 and 2007 and any proposals for development in or near the current noise policy areas should call the Council to clarify the latest status on application of noise contours.

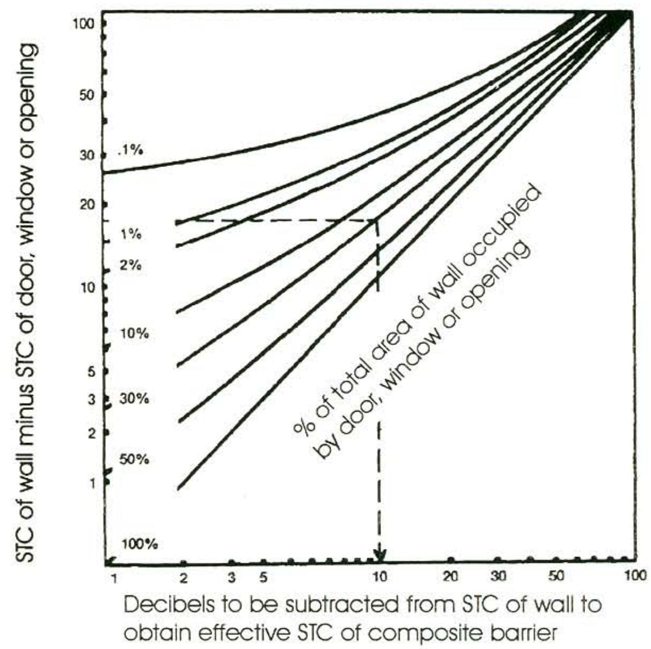
Figure A1

## Determination of Composite Wall STC Rating

Instructions on use of graph 100

1. Subtract the STC value of the door, window or opening from the STC value of the wall.
2. Enter the vertical axis of the graph at the point that matches the value from step 1.
3. Read across to the curve that represents the percentage of the total area of the wall that is taken up by the door, window, or opening.
4. Read down to the horizontal axis.
5. Subtract the value on the horizontal axis from the original STC value of the wall. The result is the composite STC value of the wall and the door, window or opening.

Source: <u>The Noise Guidebook</u>
U.S. Dept. of Housing and Urban Development



*WALL CONSTRUCTIONS*
While a variety of wall construction is available, the most common in new-home construction is the 2x6 wood stud wall with exterior and interior finishes. Until a laboratory or field measurement of this construction has been made, it is assumed here that the basic wall with insulation provides an STC of 45 in the Minnesota climate.

**Table A1**
**STC Estimated Values for Exterior Construction**

| Interior Skin and STC Rating | | | | | | |
|---|---|---|---|---|---|---|
| Exterior | 1/2" Gypsum * | 3/8" Gypsum | 2- 1/2" Gypsum | 2- 3/8" Gypsum | 1/2" SB** 1/2" GYP | 1/2" SB 3/8" GYP |
| **2 x 4 Studs** | | | | | | |
| Alum. Siding 1/2" Wood | 42 | 40 | 44 | 45 | 42 | 43 |
| 7/8" Stucco 1/2" Wood | 50 | 50 | 50 | 50 | 51 | 50 |
| 1/2" Wood Siding | 38 | 39 | 43 | 45 | 41 | 42 |
| 3/4" Wood Siding | 43 | 42 | 42 | 43 | 39 | 40 |
| | | | | | | |
| **2 x 6 Studs** | | | | | | |
| Alum. Siding 1/2" Wood | 44 | 42 | 46 | 47 | 44 | 45 |
| 7/8" Stucco 1/2" Wood | 52 | 52 | 52 | 52 | 53 | 52 |
| 1/2" Wood Siding | 40 | 41 | 45 | 47 | 43 | 44 |
| 3/4" Wood Siding | 45 | 44 | 44 | 45 | 41 | 42 |
| | | | | | | |
| **Other** | | | | | | |
| 4-1/2" Brick Veneer | 58 | 57 | 57 | 57 | 58 | 57 |
| 6" Concrete | 59 | 60 | 62 | 61 | 61 | 62 |
| 8" Concrete | 61 | 63 | 65 | 64 | 64 | 65 |
| 6" Hollow Concrete Block | 51 | 52 | 54 | 54 | 53 | 53 |
| 8" Hallow Concrete Block | 52 | 54 | 56 | 56 | 55 | 56 |
| 6" Block With 1/2" Stucco | 52 | 53 | 55 | 54 | 54 | 55 |
| 8" Block with 1/2" Stucco | 53 | 55 | 55 | 56 | 56 | 57 |

*WINDOWS, GLAZING AND WINDOW ASSEMBLIES*
It is important to note that measured STC values of glazing used in a particular window will not necessarily be achieved by the window or window assembly.

| **Table A2**<br>**Estimated STC Ratings for Typical Windows** | |
|---|---|
| Type of Window | STC |
| **Picture Window** | |
| Double Glazed | 29 |
| 1" Insulating Glass | 34 |
| | |
| **Double-Hung Window** | |
| With Insulating Glass | 27 |
| With ¾" Insulating Glass | 29 |
| With storm window | 35 |
| | |
| **Casement Window** | |
| With Insulated Glass | 28 |
| With 1" Insulating Glass | 29 |
| With Insulating high-performance Glass | 30 |
| With 1" Insulating high-performance Glass | 31 |
| With Insulating high-performance Glass & Removable Glass Panel | 32 |

| **Table A3**<br>**Selected STC Ratings for Acoustical Windows** | |
|---|---|
| Sliding Metal Windows | STC |
| 1/4", 1/3" laminated, 3/4" airspace | 38 |
| 1/4", 1/4", 2 - 1/4" airspace | 43 |
| 3/8", 1/2", 2- 1/2" airspace | 46 |
| 3/16", 1/4", 4 - 1/4" airspace | 48 |
| 1/4", 1/4" laminated, 4 - 1/4" airspace | 48 |
| 1/2", 3/8", 8 - 1/2" airspace | 56 |

*GLAZING ONLY*
These STC values are for glazing only and do not necessarily represent the window assemblies in which this glazing is used.

| **Table A4**<br>**STC Values for Glazing Only** | |
|---|---|
| Type of Glazing | STC |
| Monolithic | |
| 1/4" | 31 |
| 1/2" | 36 |
| | |
| Laminated | |
| 1/8" - 0.030"- 1/8" | 35 |
| 1/4" - 0.030"- 1/8" | 36 |
| 3/8" - 0.030"- 1/4" | 40 |
| | |
| Insulating | |
| 1/8" - 1/4" AS* - 1/8" | 28 |
| 1/4" - 1/2" AS* - 1/4" | 35 |
| 1/4" - 1" AS* - 1/4" | 37 |
| 3/16" - 4" AS* - 3/16" | 44 |
| | |
| Laminated Insulating | |
| 1/4" Laminated 1/2" AS* - 3/16" | 39 |
| 1/4" Laminated 1" AS* - 3/16" | 42 |
| 1/4" Laminated 2" AS* - 3/16" | 45 |
| 1/2" Laminated 2" AS* - 3/16" | 46 |
| 1/2" Laminated 4" AS* - 3/16" | 49 |
| | |
| Double-Laminated Insulating | |
| 1/4" Laminated 1/2" AS* 1/4" Laminated | 42 |
| 1/2" Laminated 1" AS* 1/4" Laminated | 46 |
| 1/2" Laminated 4" AS* 1/2" Laminated | 50 |

*AS = air-space

Source: *Acoustical Glazing Design Guide, Monsanto Chemical Company*

***STC RATINGS***

*DOORS AND DOOR ASSEMBLIES*

Commonly used exterior doors for homes in the Minnesota climate are solid-core, glazed and sliding.

**Table A5**
**STC Ratings for Solid & Hollow-Core Doors**

| Types of Doors | STC |
|---|---|
| Hollow-core wood with brass weather strip | 20 |
| French-style wood with 12 lights (single glazing) | 26 |
| Solid-core wood with brass weather strip | 27 |
| Hollow steel with magnetic weather strip | 28 |
| Insulated steel with compression weather strip | 28 |
| Solid-core wood with storm door | 34 |

**Table A6**
**STC Ratings for Doors with Glazing**

| Types of Doors | STC |
|---|---|
| Sliding glass (3/16" glass) | 26 |
| Sliding patio with high-performance glass | 28 |
| Swinging patio with 3/4" insulating glass | 28 |
| Patio with 1/4" laminating glass and 1/2" airspace | 30 |
| Swinging patio doors with 3/4" insulating high-performance glass | 30 |

# APPENDIX B
# REFERENCES

***BIBLIOGRAPHY***

Beranek, Leo L., ed. *Noise and Vibration Control*, McGraw-Hill, revised edition, 1988.

Davy, B.A., and S.R. Skale. *Insulation of Building against Highway Noise*, Wyle Research Laboratories, August 1977, FHWA-TS-77-02.

"Guidelines for Land-Use Compatibility with Aircraft Noise," *Metropolitan Development Guide Aviation Policy Plan,* St. Paul: Metropolitan Council, June 1986.

Harris, Davis A. *Noise Control Manual for Residential Buildings*, McGraw-Hill, 1977.

Harris, Cyril M. ed. *Handbook of Noise Control*, 3rd edition, McGraw-Hill, 1991.

Harris, Cyril M. *Noise Control in Buildings*, McGraw-Hill, 1994.

*Acoustical Glazing Design Guide*, Monsanto Company, 1996.

*Raleigh-Durham International Airport: New Construction Acoustical Design Guide*, Arlington, VA: Wyle Laboratories, 2001.

"Study of Soundproofing Public buildings Near Airports," Trans Systems Corporation in association with Wyle Research Laboratories, April 1997, DOT-FAA-AEQ-77-9.

Tocci, Gregory C. et al. "Glazing [&] Sound Transmission Loss Studies." Paper presented at 11th Meeting of the Acoustical Society of America, Cleveland, May 1986.

Tocci, Gregory C. "A Comparison of STC and EWR for rating Glazing Noise Reduction," *Sound and Vibration,* 219 No. 10, October 1977.

“Sound Transmission Control,” Chapter 35, *Uniform Building Code,* Whittier CA: International Conference of Building Officials, 1977.

*Quieting in the Home,* Washington DC: U.S. Environmental Protection Agency, October 1978.

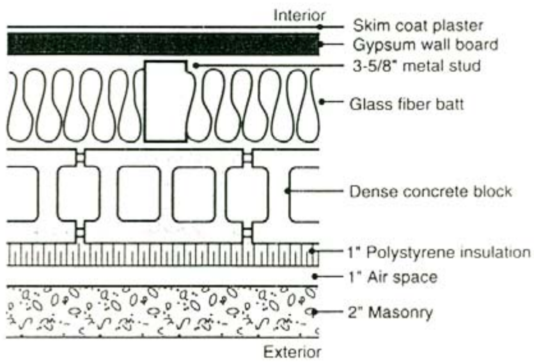
Walker, Kieth W. "Single Number Ratings for Sound Transmission Loss," *Sound and Vibration* 22 No. 7, July 1988.

*Standard Guide for Field Measurement of Airborne Sound Insulation of Building Façade and Façade Elements*, E966-92, American Society for Testing Materials.

***MANUFACTURES AND SOURCES***

This partial listing of manufactures of windows and doors is intended to provide the user of this Guide with a representative listing of high quality and acoustically-rated windows. The list, which is based upon previous projects in the Twin Cities metropolitan area, is not intended to be complete or comprehensive.

| | |
|---|---|
| Anderson Windows, Inc.<br>100 4th St. N. (PO Box 12)<br>Bayport MN 55003-1096 | Mon-Ray<br>8224 Olson Memorial Highway<br>Minneapolis MN 55427-4713 |
| H Window Company<br>1324 East Oakwood Dr.<br>Monticello MN 55362 | Overly Door company<br>575 West Otterman St. (PO Box 70)<br>Greensburg PA 15601-0070 |
| Hess Manufacturing Company<br>Box 127, Route 997<br>Quincy PA 17247 | Peerless Products, Inc.<br>15500 College Blvd. Suite 750<br>Lenexa KS 66219 |
| Larson Manufacturing Company<br>2333 Eastbrook Dr.<br>Brookings SD 57006 | Pella Corporation<br>102 Main street<br>Pella IA 50219-2147 |
| Loewen Windows<br>600 Lakeview Parkway<br>Vernon Hills IL 60061 | Republic Window and Doors<br>930 West Evergreen Ave.<br>Chicago IL 60622 |
| Marvin Windows & Doors<br>Warroad MN 56763 | St. Cloud Window, Inc.<br>PO Box 1577<br>St. Cloud MN 56302-1577 |



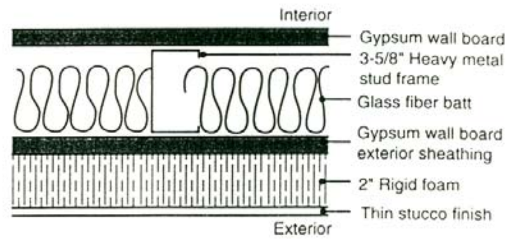

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 67 | 60 | 64 | 66/58 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior side | +2 dB |
| Delete glass fiber batt | –6 dB |
| Add loose insulation to block cells | +2 dB |
| Delete polystyrene insulation | 0 dB |
| Double thickness of exterior masonry | +2 dB |

**Figure 1.15a**



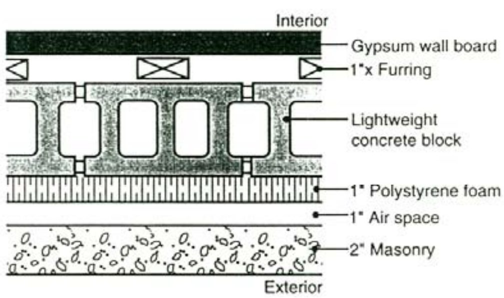

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 49 | 48 | 51 | 52/45 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior side | +5 dB |
| Delete glass fiber batt | –6 dB |
| Halve thickness of urethane foam | –3 dB |
| Double thickness of urethane foam | +1 dB |
| Add resilient channels between interior GWB and stud | +4 dB |

**Figure 1.15b**



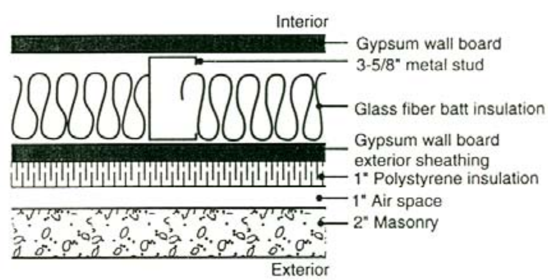

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 58 | 51 | 55 | 57/49 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior side | +2 dB |
| Replace 1"x furring with 1/2" resilient channels | +3 dB |
| Delete 1"x furring, adhere GWB to block | –3 dB |
| Add loose insulation to block cells | +2 dB |
| Delete polystyrene foam | 0 dB |
| Double thickness of exterior masonry | +2 dB |

**Figure 1.15c**



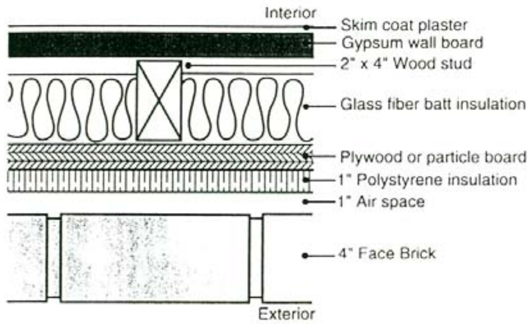

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 52 | 45 | 49 | 51/43 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior side | +2 dB |
| Delete glass fiber batt | –5 dB |
| Double masonry thickness | +3 dB |
| Delete polystyrene insulation | 0 dB |

**Figure 1.15d**



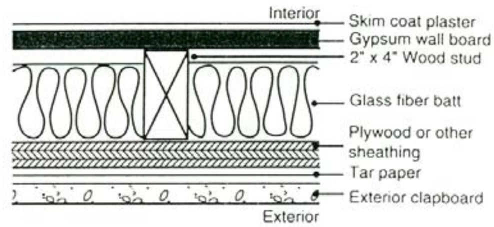

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 54 | 47 | 51 | 53/45 |

**Adjustments**

| | |
|---|---|
| Add resilient channels between interior GWB and stud | +8 dB |
| Delete polystyrene foam | 0 dB |
| Replace brick with 2" solid masonry | –3 dB |
| Replace 4" brick with 6" hollow masonry units | –1 dB |

**Figure 1.15e**



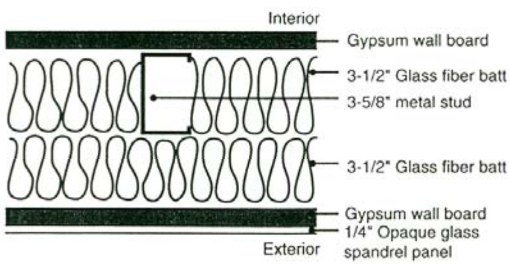

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 40 | 34 | 39 | 41/30 |

**Adjustments**

| | |
|---|---|
| Add resilient channels between interior GWB and stud | +8 dB |
| Replace tar paper and clapboard with foam insulation and vinyl or aluminum siding | –2 dB |
| Delete skim coat | –1 dB |

**Figure 1.15f**



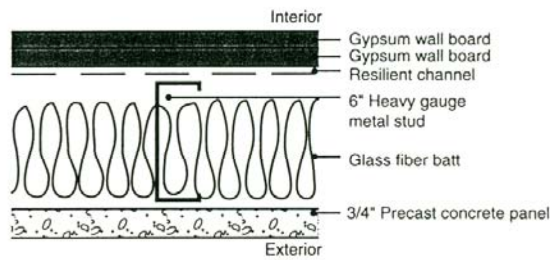

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 55 | 50 | 54 | 55/48 |

**Adjustments**

| | |
|---|---|
| Delete exterior GWB | –3 dB |
| Delete glass fiber batt | –5 dB |
| Add interior GWB | +2 dB |
| Increase glass to 1/2" thickness | +2 dB |
| Add Saflex® interlayer | +4 dB |

**Figure 1.15g**



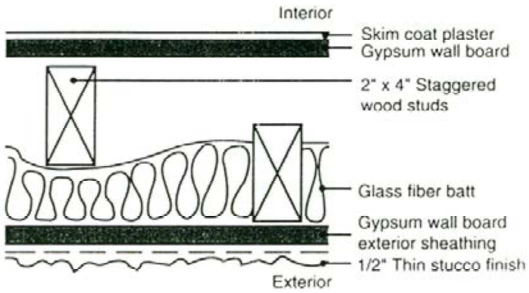

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 63 | 53 | 57 | 58/49 |

**Adjustments**

| | |
|---|---|
| Delete 1 layer GWB | –3 dB |
| Delete resilient channels | –13 dB |
| Delete both batt and resilient channels | –15 dB |
| Delete batt, leave resilient channels in | –8 dB |
| Double concrete panel thickness | +2 dB |

**Figure 1.15h**



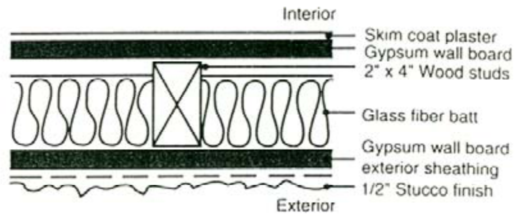

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 53 | 44 | 47 | 48/41 |

**Adjustments**

| | |
|---|---|
| Add resilient channels | 0 dB |
| Add one layer GWB to interior side | +1 dB |
| Delete exterior GWB sheathing, apply lath and stucco to studs | -5 dB |
| Substitute equal thickness plywood for GWB | 0 dB |
| Delete glass fiber batt | -6 dB |
| Change wood studs to metal studs | 0 dB |

**Figure 1.15i**



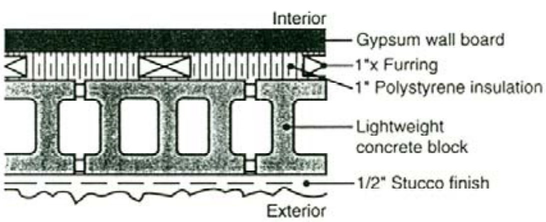

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 40 | 29 | 34 | 36/25 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior | +3 dB |
| Delete glass fiber batt | -3 dB |
| Add resilient channels to wood studs | |
| with glass fiber in cavity | +9 dB |
| without glass fiber in cavity | +4 dB |
| Delete exterior GWB sheathing, apply lath and stucco to studs | -3 dB |
| Substitute equal thickness plywood for GWB | 0 dB |
| Substitute heavy metal studs for wood studs | +5 dB |

**Figure 1.15j**



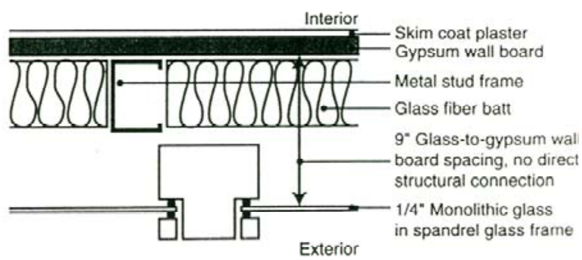

**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 50 | 48 | 50 | 52/46 |

**Adjustments**

| | |
|---|---|
| Add one layer GWB to interior side | +2 dB |
| Replace 1"x furring with 1/2" resilient channels | +1 dB |
| Delete 1"x furring, adhere GWB to block | -2 dB |
| Add loose insulation to block cells | +2 dB |
| Delete polystyrene insulation | 0 dB |
| Use dense concrete block instead of lightweight | +3 dB |

**Figure 1.15k**




**A-Weighted Noise Reduction (dBA)**

| Estimated STC | Aircraft | Traffic | Rail |
|---|---|---|---|
| 50 | 52 | 54 | 53/50 |

**Adjustments**

| | |
|---|---|
| Replace 1/4" monolithic with 1/4" laminated | +4 dB |
| Increase glass-to-GWB spacing to 12" | +1 dB |
| Increase glass thickness to 1/2" | +5 dB |
| Use standard 1" insulating glass in lieu of 1/4" monolithic glass | +1 dB |
| Add one layer of GWB | +5 dB |
| Delete skim coat plaster | -1 dB |
| Delete glass fiber batt | -10 dB |

**Figure 1.15l**

**NOTE:**

Find the exterior wall construction that most closely resembles that designed.

Use the adjustments to account for differences between actual exterior wall construction and those shown in this figure

Adjustments are applicable to estimated STC and OITC ratings and $R_w$s, and to aircraft, traffic and rail noise reductions

Two noise reduction values are provided for rail transportation noise sources. The first is for rolling stock, electric self-propelled vehicles and non-diesel locomotive trains. The second is for diesel powered locomotive trains

## Laboratory Measured STC and OITC Ratings and RW for Various Glass Configurations

| TEST NO.[1] | Nominal Thickness (Configuration) | STC | OITC[2] | Rw | U-Value[3] Summer | Winter |
|---|---|---|---|---|---|---|
| **Monolithic** | | | | | | |
| TL 85-169 | 1/4" | 31 | 29 | 32 | 1.01 | 1.08 |
| TL 85-198 | 1/2" | 36 | 33 | 37 | .97 | 1.03 |
| **Laminated** | | | | | | |
| TL 85-218 | 1/4" (Lami - 0.030" - Lami.) | 35 | 31 | 35 | 1.00 | 1.06 |
| TL 85-170 | 1/4" (1/8" - 0.030 - 1/8") | 35 | 31 | 35 | .99 | 1.05 |
| TL 85-224 | 1/4" (1/8" -0.060 - 1/8") | 35 | 31 | 35 | .97 | 1.03 |
| TL-85-234 | 1/4" (1/8" -0.045"- 1/8") | 35 | 32 | 35 | .98 | 1.04 |
| TL 85-200 | 3/8" (3/16" 0.030 3/16") | 36 | 31 | 36 | .97 | 1.03 |
| TL 85-229 | 3/8" (1/4" 0.030 1/8") | 36 | 33 | 36 | .97 | 1.03 |
| TL 85-223 | 3/8" (1/4" 0.060 1/8") | 37 | 33 | 37 | .95 | 1.00 |
| TL 85-225 | 1/2" (1/4" 0.030" 1/4") | 38 | 34 | 38 | .95 | 1.01 |
| TL 85-232 | 1/2" (1/4" 0.045" 1/4") | 38 | 34 | 38 | .94 | .99 |
| TL 85-228 | 1/2" (1/4" 0.060" 1/4") | 39 | 34 | 39 | .93 | .98 |
| TL 85-222 | 5/8" (3/8" 0.030" 1/4") | 40 | 36 | 40 | .93 | .99 |
| TL 85-230 | 3/4" (1/2" 0.060" 1/4") | 41 | 36 | 41 | .90 | .95 |
| **Insulating[4,5]** | | | | | | |
| TL 85-212 | 1/2" (1/8" 1/4"AS 1/8") (sealed) | 28 | 26 | 30 | .62 | .57 |
| TL 85-213 | 5/8" (1/8" 3/8"AS 1/8") (sealed) | 31 | 26 | 32 | .57 | .52 |
| TL 85-294 | 1" (1/4" ½"AS 3/16") (sealed) | 35 | 28 | 35 | .54 | .48 |
| TL 85-215 | 1-3/8" (3/16" 1"AS 3/16") (sealed) | 35 | 27 | 37 | .54 | .48 |
| TL 85-293 | 1-1/2" (1/4" 1"AS 1/4") (unsealed) | 37 | 30 | 37 | .52 | .48 |
| TL 85-216 | 4-3/8" (3/16" 4"AS 3/16") (unsealed) | 44 | 35 | 44 | .52 | .48 |
| **Laminated Insulating[4,5,6]** | | | | | | |
| TL 95-296 | 5/8" (1/8" 0.030" 1/8" 1/4"AS 1/8") (sealed) | 35 | 31 | 35 | .61 | .56 |
| TL 85-189 | 13/16" (1/8" 0.030" 1/8" 3/8" AS 3/16") (sealed) | 37 | 31 | 37 | .55 | .50 |
| TL 85-238 | 15/16" (1/8" 0.030" 1/8" 1/2"AS 3/16") (sealed) | 39 | 31 | 39 | .53 | .48 |
| TL 85-235 | 1" (1/8" 0.030" 1/2" 1/2"AS 1/4") (sealed) | 39 | 31 | 39 | .53 | .48 |
| TL 85-192 | 1-1/8" (1/8" 0.030" 1/4" 1/2"AS 1/4") (sealed) | 40 | 31 | 40 | .53 | .47 |
| TL 85-239 | 1-7/16" (1/8" 0.030" 1/8" 1"AS 3/16") (unsealed) | 42 | 33 | 42 | .51 | .48 |
| TL 85-173 | 2-7/16" (1/8" 0.030" 1/8" 2"AS 3/16") (unsealed) | 45 | 35 | 45 | .51 | .48 |
| TL 85-194 | 2-11/16" (1/4" 0.030" 1/4" 2"AS 3/16") (unsealed) | 46 | 38 | 46 | .50 | .47 |
| TL 85-196 | 2-7/8" (1/4" 0.030" 1/4" 2"AS 3/8") (unsealed) | 46 | 42 | 47 | .49 | .46 |
| TL 95-298 | 1-11/16" (1/4" 0.030" 1/4" 1"AS 3/16") (unsealed) | 47 | 36 | 47 | .52 | .47 |
| TL 85-174 | 4-7/16" (1/8" 0.030" 1/8" 4"AS 3/16") (unsealed) | 48 | 39 | 48 | .51 | .48 |
| TL 85-195 | 4-11/16" (1/4" 0.030" 1/4" 4"AS 3/16") (unsealed) | 49 | 41 | 49 | .50 | .47 |
| TL 85-197 | 4-7/8" (1/4" 0.030" 1/4" 4"AS 3/8") (unsealed) | 49 | 44 | 50 | .49 | .46 |
| TL 85-240 | 4-7/8" (1/2" 0.030" 1/4" 4"AS 1/8") (unsealed) | 49 | 40 | 49 | .49 | .46 |
| **Double Laminated Insulating[4,5,6]** | | | | | | |
| TL 85-172 | 1-1/16" (1/8" 0.030" - 1/8" – 1/2"AS - 1/8" 0.030" - 1/8") (sealed) | 42 | 33 | 42 | .52 | .47 |
| TL 95-299 | 1-9/16" (1/8" 0.030" - 1/8" – 1" AS - 1/8" 0.030" 1/8") (unsealed) | 46 | 37 | 46 | .52 | .47 |
| TL 85-236 | 1-13/16" (1/4" 0.030 - 1/4" 1"AS 1/8" 0.060 1/8") (unsealed) | 46 | 34 | 46 | .49 | .46 |
| TL 85-221 | 5-1/16" (1/4" 0.060 1/4" 4"AS 1/4" 0.030 1/4") (unsealed) | 50 | 42 | 50 | .48 | .45 |
| TL 85-220 | 5-5/16" (1/2" 0.060" 1/4" 4"AS 1/4" 0.030 1/4") (unsealed) | 50 | 42 | 50 | .47 | .44 |
| TL 85-237 | 4-13/16" (1/4" 0.030 1/4" 4"AS 1/8" 0.060" 1/8") (unsealed) | 51 | 44 | 51 | .49 | .46 |
| TL 95-301A | 4-9/16" (1/8" 0.030" 1/8" 4"AS 1/8" 0.030 1/8") (unsealed) | 52 | 38 | 51 | .51 | .47 |
| TL 95-302 | 4-13/16" (1/8" 0.030" 1/8" 4"AS 1/4" 0.060 1/4") (unsealed) | 53 | 45 | 53 | .49 | .46 |
| **Triple Glazing[4,6,7]** | | | | | | |
| TL 95-294 | 1-3/4" (1/4" - 1/2" AS - 1/4" - 1/2" AS - 1/4") (sealed) | 39 | 31 | 39 | .37 | .31 |
| TL 95-295 | 1-9/16" (1/4" Lam-1/2" AS – 1/4" Lam - 1/2" AS - 1/4" Lam)(unsealed) | 44 | 33 | 44 | .36 | .30 |
| TL 95-297 | 2-1/4" (1/4" - 1" AS - 1/4" - 1/2" AS - 1/4") (unsealed) | 46 | 37 | 47 | .36 | .30 |
| TL 95-300 | 2-5/16" (1/4" Lam - 1" AS - 1/4" Lam - 1/2" AS - 1/4" Lam) (unsealed) | 49 | 39 | 49 | .35 | .30 |

NOTE: The data and information set forth are based on samples tested and are not guaranteed for all samples or applications. Riverbank Acoustical Laboratories.

[1] RAL TL85 & TL95 sound transmission loss tests are in accordance with ASTM E90. STC ratings have been determined from TL data using ASTM E413. (See Section 3 for actual TL data.)
[2] Estimated. Computation based on a one-third octave band TL at 80 Hz (which was not measured in a laboratory) that is equal to the 100 Hz one-third octave band TL minus 2dB.
[3] The overall heat transfer coefficient in BTU/hr/sq ft/degree Fahrenheit.
[4] AS = air space.
[5] Unsealed configurations are individual glass panels separated by wood stops and caulked into the laboratory test opening using glazing putty.
[6] 0.030", 0.060" - Salfex interlayer thickness.
[7] The second and third glass panels of the triple glass configurations tested are sealed insulating glass units. After sealed IG units were installed into the laboratory test opening, the first glass panel and wood spacers were used to complete the triple glass configurations.

# APPENDIX C
# MODEL NOISE ATTENUATION ORDINANCE

***BACKGROUND***

The Model Noise Attenuation Ordinance was prepared to assist communities in implementing the Land-Use Compatibility Guidelines for Aircraft Noise. These guidelines are contained in Appendix H of the *Transportation Policy Plan* and replace those in the 1996 *Aviation Policy Plan*. The guidelines are used by the Metropolitan Council to review local comprehensive plans and development proposals.

The model ordinance reflects the Metropolitan Area Aircraft Noise Attenuation Act as enacted by the Minnesota Legislature in 1987. This enabling law allows communities to establish aircraft overlay zoning and local building codes stricter than the state uniform building code (MS 473.192). The model ordinance provides for:

- Finds that aircraft noise is a problem for the city and its citizens;
- Establishes aircraft noise overlay zoning districts;
- Identifies exterior noise levels and interior noise performance standards;
- Identifies compatible/incompatible land uses;
- Establishes structure acoustical requirements; and,
- Defines process for inspection and enforcement.

***MODEL ORDINANCE***

**Ordinance ______**

*An ordinance promoting the health, safety and general welfare of the citizens of [insert name of affected local governmental unit], Minnesota, by amending the zoning ordinance and code and by adopting new sections, requiring compliance with noise reduction standards in building construction.*

**Section 1 - Statutory Authority**

*This ordinance is adopted pursuant to MS 473.192 (Supp. 1987), "Metropolitan Area Aircraft Noise Attenuation Act".*

**Section 2 - Findings of Fact**

*The City of [insert name of affected local governmental unit] finds that development within certain areas of the city is impacted by aircraft noise; that said noise is beyond the regulatory authority of the city to control; that certain uses of land are inappropriate in areas of high aircraft noise; that some structures do not adequately attenuate aircraft noise resulting in negative impacts on health, safety and welfare of the residents or inhabitants of the structures that, through proper construction methods, the means exist to attenuate aircraft noise to interior levels which alleviate such negative impacts; and that the requirements of this ordinance are necessary to promote and preserve the health, safety and welfare of the citizens of [ insert name of local unit of government ].*

**Section 3 - Purpose**

*The purpose of this ordinance is to require that new or redeveloped buildings within the City of [insert name of local governmental unit] be constructed with materials and in such a manner that aircraft noise is attenuated by the structure to an interior level which has no adverse impact on the health, safety and general welfare of the residents, all in accordance with the Metropolitan Council's Guidelines for Land-Use Compatibility with Aircraft Noise. These guidelines are part of the Transportation Policy Plan of the Metropolitan Development Guide.*

**Section 4 - Definitions**

*For purposes of this ordinance the terms defined in this section have the meanings given them in this section*.

*AIRCRAFT NOISE ZONE* **-** *Aircraft Noise Zone means any one of the four zones identified on the maps included under Section 7 and incorporated herein.*

*DBA - dBA means a unit of sound pressure level weighted by use of the "A" metering characteristics and weighting as specified in the American National Standards Specification for Sound Meters (ANSI S1.4-1983), which is hereby incorporated by reference. DBA is also referred to as an A-weighted decibel.*

*LDN* **-** *LDN means the day-night average level, or the 24-hour equivalent continuous sound time (time-averaged A-weighted sound level) from midnight to midnight, obtained after the addition of 10 dBA to sound levels measured from 10 p.m. to 7 a.m.*

*LOW-FREQUENCY NOISE* **-** *Noise with a frequency of 100 Hz or lower is generally considered low frequency noise, although a number of different metrics are used to represent low-frequency noise levels. This noise can easily penetrate structures and is not attenuated with normal construction practices. A major effect of low frequency noise is perceived vibration and rattling of items within a structure. Measures for addressing low-frequency noise are being assessed by the Federal Aviation Administration.*

*NOISE-REDUCTION LEVEL – Noise-reduction level means the difference between the exterior and interior sound level, expressed in dBA, which is achieved by the intervening structure.*

*RECOGNIZED ACOUSTICAL SPECIALIST* **-** *A recognized acoustical specialist means a person qualified by education and experience to conduct sound analysis of buildings and approved for such purpose by the city's building inspector. The approved individual shall have at least three years of experience in the field of sound control; a degree from a recognized institute of higher learning in acoustics or a closely related discipline; demonstrated expertise in the process of sound analysis of buildings.*

*SOUND - Sound means energy that is transmitted by pressure waves in the air or in other materials and is the objective cause of the sensation of hearing. It is commonly called noise if it is unwanted.*

*SOUND ATTENUATION* **-** *Sound attenuation means the reduction in sound level which occurs between the source and receiver.*

*SOUND LEAK - Sound leak means an opening in a structure through which sound can pass. Sound leaks are often extremely small holes or cracks. In general, an air leak is a sound leak.*

*SOUND LEVEL* - *Sound level means the level of sound pressure measured with a sound level meter and one of its weighting (frequency) networks. When A-weighting is used, the sound level is expressed as dBA.*

*SOUND TRANSMISSION CLASS (STC)* - *Sound transmission class means a single-number rating for describing the degree of sound transmission loss specified for a wall, window, partition or other building element. The higher the STC, the more attenuation the building element will afford.*

**Section 5 - Scope and Effect**

*The aircraft noise zones established by this ordinance shall overlay the zoning districts established by Ordinance No.____ adopted [insert date] so that any parcel of land lying in an overlay zone shall also lie in one or more of the established zoning districts. Territory within a given overlay zone shall be subject to the requirements established by the other applicable ordinances and regulations of the city. Within each adopted overlay zone, all uses shall be permitted in accordance with the regulations for the underlying zoning districts, provided, however, that the appropriate building permit is first obtained and provided further that no use designated as incompatible on the Noise Compatibility Table, and incorporated herein, shall be permitted.*

*This ordinance applies to all construction requiring a building permit after the effective date of this ordinance except decks, patios, swimming pools, breezeways and similar outdoor uses and remodeling or rehabilitation of an existing residential building, nor to the construction of an appurtenance to an existing residential building. In case of conflict between this ordinance and any other applicable codes or ordinances, the more restrictive requirement shall be met.*

**Section 6 - Prerequisites to Issuance of Building or Occupancy Permit**

*Any application for a City of [insert name of local governmental unit] building or occupancy permit pertaining to land located in an Aircraft Noise Zone must demonstrate compliance with the provisions of this ordinance prior to the issuance of such permit.*

**Section 7 - Establishment of Zones**

*The following aircraft noise zones are hereby established as part of the zoning ordinance of [insert name of local governmental unit].*

- *Aircraft Noise Zone 1* — *DNL 75+*
- *Aircraft Noise Zone 2* — *DNL 74 - 70*
- *Aircraft Noise Zone 3* — *DNL 69 - 65*
- *Aircraft Noise Zone 4* — *DNL 64 - 60*
- *Noise Buffer Zone** — *1- Statute Mile (for MSP)*<br>*DNL 60noise contour for areas outside MUSA*<br>*(for Reliever Airports)*

[* Note: Application of a Noise Buffer Zone is at the discretion of the affected community.]

*These zones apply to the following airports:*
*Minneapolis-St. Paul International, St. Paul Downtown, Airlake, Anoka County-Blaine, Crystal, Flying Cloud, Lake Elmo and South St. Paul Municipal airport.*

*The boundaries of the Aircraft Noise Zones are as delineated on the diagram attached hereto for the following airport(s) [insert name of airport facility].*

**Section 8 - Noise Compatibility Tables**

*The noise compatibility table is adapted from the Metropolitan Council's Guidelines for Land-Use Compatibility with Aircraft Noise. The noise reduction level numbers, expressed in dBA, specify for each type of land use the amount of interior sound level reduction necessary for the use to be compatible in the applicable aircraft noise zone.*

*All construction or reconstruction requiring a building permit and located within an aircraft noise zone (except remodeling or rehabilitation of an existing residential building), shall be constructed in such a way that the applicable noise level reduction requirements contained in the noise compatibility table is met or exceeded. Where a particular structure contains different land uses, the more stringent requirements of the applicable table shall apply, except where it is architecturally possible to achieve the appropriate noise reduction level for each different use, and the uses are acoustically separated by a wall or partition with a minimum STC of 25.*

**Section 9 - Enforcement**

*The City of [insert name of local governmental unit] building inspector is authorized to enforce the provisions of this ordinance pursuant to Sections 10 and 11.*

**Section 10 - Plans and Specifications**

*A. All applicants for a building or occupancy permit shall include with the application all plans, specifications or other information required by this ordinance. The plans and specifications shall describe in sufficient detail all pertinent features of the building, building materials, heating and ventilation systems, including but not limited to the STC ratings of roof-ceilings, walls, window, and doors; and other pertinent data as may be requested by the building inspector to indicate conformance with the applicable noise reduction level requirements as specified in the noise compatibility tables. To assure the elimination of sound leaks, the plans and specifications shall demonstrate compliance with the following standards.*

1. *All mechanical ventilation systems shall be installed that will provide the minimum air circulation and fresh-air supply requirements as provided in the Uniform building Code for the proposed occupancy without the need to open any exterior doors or windows.*
2. *The perimeter of all exterior windows and door frames shall be sealed airtight to the exterior wall construction.*
3. *Fireplaces shall be equipped with well-fitted chimney cap devices.*
4. *All ventilation ducts, except range hoods, connecting interior space to outdoors shall be provided with a bend such that no direct line of sight exists from the exterior to the interior through the vent duct.*
5. *Doors and windows shall be constructed so that they are close fitting. Weather-stripping seals shall be incorporated to eliminate all edge gaps.*
6. *All penetrations through exterior walls by pipes, ducts, conduits and the like shall be caulked airtight to the exterior construction.*

*The building inspector may require that plans and specifications be certified by a Recognized Acoustical Specialist for compliance with the ordinance.*

*B. Within 30 days of receipt of appropriate plans and specifications, the building inspector shall approve or reject the plans based upon the ability of the proposed materials and construction techniques to adequately attenuate noise. The building inspector shall approve the plans and specifications if:*

1. *They adequately document the use of construction assembly that meet or exceed the STC ratings required by the following table:*

| **Table __<br>STC Ratings required for Building Elements** | | | | |
|---|---|---|---|---|
| Specified<br>Noise Level Reduction | Required STC Rating Needed for Compliance* | | | |
| dBA | Roof-Ceiling | Walls | Windows | Doors |
| 20 | 40 | 40 | 30 | 20 |
| 25 | 45 | 45 | 35 | 25 |
| 30 | 50 | 50 | 40 | 30 |
| 35 | 55 | 55 | 45 | 35 |
| 40 | 60 | 60 | 50 | 40 |

*All values -2 STC. The STC laboratory test of construction materials and assemblies must be conducted according to requirements of the American Society of Testing and Materials (ASTM E90 or ASTM E 336); or

2. *They have been certified by a Recognized Acoustical Specialist as achieving the interior noise level reduction required by the applicable portion of the noise compatibility table.*

   *In the event that the drawings are rejected, the reasons for such rejections shall be submitted to the applicant in writing. No construction shall occur prior to the approval of appropriate plans and specifications. All construction shall be performed in accordance with the approved plans and specifications. Construction done in accordance with the approved plans and specifications as determined by the building inspector shall be deemed to meet the noise attenuation requirements of this ordinance.*

**Section 11 - Inspections**

A. *All construction work for which a building permit is required shall be subject to inspection by the building inspector. Inspection of noise attenuation work shall be performed during the required building inspections specified by the City of [insert name of local governmental unit] building code.*

B. *Field Testing. When inspection indicates that the construction is not in accordance with the approved plans, the building inspector may order such corrective action as may be necessary to meet the noise attenuation requirements of this ordinance. In lieu of performing such corrective action, a building owner may submit a test report based upon field tests showing compliance with the noise reduction level requirements contained in the applicable noise compatibility table. The field test shall be performed in accordance with the American Society for Testing Materials (ASTM) Standard E 336-07 Part A.1.2.2. Outside to Inside (Level reduction).*

**Section 12 - Fees**

*The building inspector is authorized to collect fees to cover administrative and enforcement costs. This fee shall be $ _____ .*

**Section 13 - Severability**

*If any part of this ordinance is held to be unconstitutional or otherwise illegal, the remainder of this ordinance shall remain in force and effect as if such unenforceable provision had not been included herein.*

# APPENDIX D
# APPLICATION OF THE NOISE BUFFER ZONE

Use of a buffer zone is encouraged; but it is a voluntary effort, and implementation is at the discretion of the affected community. The rational and specific noise designation of each land-use category in the noise buffer zone is described below for guidance in application by the affected community.

### *MSP BUFFER ZONE*

The Aviation Element of the *Transportation Policy Plan* includes a noise policy area designation for the noise contours established at MSP International Airport. The noise policy area includes the [mitigated] 2007 noise exposure map prepared in the FAR Part 150 noise program that has been submitted for FAA review/approval. The noise buffer zone is described as extending one statute mile beyond the noise zone 4 (DNL 60-64) contour line.

### *RELIEVER AIRPORTS BUFFER ZONE*

The buffer zone at the general aviation reliever airports is defined as the DNL 60 noise contour area that falls outside the metropolitan urban service area boundary. Application of the buffer zone is at the discretion of the affected community.

### *APPLICATION*

The land-use compatibility table identifies uses for each noise exposure zone as INCO, COND, PROV, and COMPS. These land-use designations are linked to descending noise levels from Noise Zone 1 to Noise Zone 4. To extend Noise Zone 4 into the buffer zone, the acoustic gradations link needs to be maintained. Thus, for any particular land use in Noise Zone 4, the corresponding designation for the buffer zone would be the next lowest designation. For example, if a land use in Noise Zone 4 is designated as COND, that use in the buffer zone would be designated as PROV.

Under the Model Noise Ordinance (Section 5), it states:

> Territory within a given [noise] overlay zone shall be subject to the requirements established by the other applicable ordinances and regulations of the city. Within each adopted overlay zone, all uses shall be permitted in accordance with the regulations for the underlying zoning districts; provided, that the appropriate building permit is first obtained and provided further that no use designated as inconsistent [INCO] on the Noise Compatibility Table, and incorporated herein, shall be permitted. This ordinance applies to all construction requiring a building permit after the effective date of this ordinance except decks, patios, swimming pools, breezeways and similar outdoor uses and remodeling or rehabilitation of an existing residential building, nor to appurtenance to an existing residential building. In the case of conflict between this ordinance and any other applicable codes or ordinances, the more restrictive requirement shall be met. [Underline added.]

The term "additions" applies to extensions or expansion of the homes foundation footprint, including indoor occupancy and use. The footnote for Table 4 in Appendix H of the 2004 *Transportation Policy Plan* also states, "These performance standards do not apply to buildings, accessory buildings or portions of buildings that are not normally occupied by people. The term "appurtenance" is defined as "the visible, functional or ornamental objects accessory to and part of a building" (*Planners Dictionary,* American Planning Association, PAS Report No. 521/522).

***REVIEW PROCESS***

In review of community comprehensive plan updates or amendments, the Council has requested that it be notified if the city has officially adopted a noise buffer zone. If so, the noise zones and buffer area should be included in the comprehensive plan and reflected in local codes/ordinances.

In general, the review of COND projects within the buffer zone would be accomplished by the city; and the Council would review COND projects located within Noise Zones 1 through 4. Within these zones, any land use [project] defined as COND under the compatibility guidelines and that is identified by the city as a PUD or requires a different designation would be processed like a comprehensive plan amendment.

# APPENDIX E
# AIRPORTS: NOISE POLICY AREA MAPS

Noise contours for MSP International Airport were prepared in the FAR PART 150 noise compatibility program update. This program has been submitted to the Federal Aviation Administration for review and approval. At the other regional airports the contours have been prepared as part of the long-term comprehensive plan (LTCP) and environmental evaluations. The LTCPs are periodically updated, but not necessarily on the same schedule; therefore, the contour dates will vary.

The Council uses the noise contours primarily for review of local community comprehensive plans and plan amendments to improve overall land-use compatibility. The Metropolitan Airports Commission and other airport owners use the contours primarily to address existing incompatible land uses that require corrective mitigation. They also use the contours in conjunction with Noise Abatement Operations Plans at each airport to address day-to-day operational issues.

These various contours are included in the Council's Regional Transportation Policy Plan as part of the *Land-use Compatibility Guidelines for Aircraft Noise* (Appendix H). These guidelines are applied at all communities located around the regions public airports.

Noise policy contours are in effect until a future update is technically reviewed and adopted. A number of airport LTCPs will be updated in 2006 and 2007. Developers/Builders are encouraged to contact the respective community from which a permit is needed for projects located in or near noise policy areas.

### CRYSTAL AIRPORT: NOISE POLICY AREA 2013

The Crystal Airport aircraft noise contours were last prepared in 1993 based upon a 2013 planning horizon. The Metropolitan Airports Commission will be updating the airports Long-Term Comprehensive Plan in 2006 and it is anticipated that new aircraft noise information will be prepared. Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

### AIRLAKE AIRPORT: NOISE POLICY AREA 2015

The Airlake Airport aircraft noise contours were last prepared in 1995 based upon a 2015 planning horizon. The Metropolitan Airports Commission will be updating the airport's Long-Term Comprehensive Plan (LTCP) in 2006 and it is anticipated that new aircraft noise information will be prepared. Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## LAKE ELMO AIRPORT: NOISE POLICY AREA 2010

The Lake Elmo Airport aircraft noise contours were last prepared with a 1989 base year and a 2010 planning Horizon. The Metropolitan Airports Commission will be updating the airport's Long-Term Comprehensive Plan (LTCP) in 2006 and it is anticipated that new aircraft noise information will be prepared.  Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## ST. PAUL DOWNTOWN AIRPORT: NOISE POLICY AREA 2020

The St. Paul Downtown Airport aircraft noise contours were last prepared in 1998 based upon a 2020 planning horizon.  The Metropolitan Airports Commission expects to be updating the airport's Long-term Comprehensive Plan (LTCP) by 2007 and it is anticipated that new aircraft noise information will be prepared. Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## ANOKA COUNTY – BLAINE AIRPORT: NOISE POLICY AREA 2015

The Anoka County-Blaine Airport aircraft noise contours were last prepared in 1995 based upon a 2015 planning horizon.   The Metropolitan Airports Commission expects to be updating the airport's Long-term Comprehensive Plan (LTCP) by 2007 and it is anticipated that new aircraft noise information will be prepared.  Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## FLYING CLOUD AIRPORT: NOISE POLICY AREA 2010

The Flying Cloud Airport aircraft noise contours were last prepared in 1999 based upon a 2010 planning horizon. The Metropolitan Airports Commission expects to be updating the airport's Long-term Comprehensive Plan (LTCP) by 2007 and it is anticipated that new aircraft noise information will be prepared.  Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## SOUTH ST. PAUL AIRPORT: NOISE POLICY AREA 1982

The South St. Paul Airport aircraft noise contours were last prepared in 1977 based upon an assumed noise peaking planning horizon by 1982.  The City of South St. Paul will be updating its 1998 community comprehensive plan and the 2002 airport  layout plan (ALP) by 2008; It is anticipated that new aircraft noise information will be prepared.  Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

## FOREST LAKE AIRPORT: NOISE POLICY AREA

The Forest Lake Airport is a low-activity airfield that has transitioned from a private to a public owned facility.  The City will be updating its community comprehensive plan and expected to prepare an airport LTCP by 2008.  It is anticipated that new aircraft noise information will be prepared.  Update of the *Transportation Policy Plan* and *Builder's Guide* will be made as appropriate for the noise policy area.

**Table 5**
**Typical Land Use By Standard Land-use Coding Manual Codes (SLUCM)**

| Type of Land Use | Code Numbers and Specific Uses | |
|---|---|---|
| **Residential** | | |
| - Single/Multiplex with Individual Entrance | | |
| | 11 | Household units |
| | 11.11 | Single units - detached |
| | 11.12 | Single units - semi detached |
| | 11.13 | Single units - attached row |
| | 11.21 | Two units - side-by-side |
| | 11.22 | Two units - one above the other |
| - Multiplex/Apartment with Shared Entrance | | |
| | 11.31 | Apartments - walk-up |
| | 11.32 | Apartments - elevator |
| | 12 | Group quarters |
| | 13 | Residential hotels |
| | 14 | Mobile home parks or courts |
| - Educational and Medical, Schools, Churches, Nursing Homes | | |
| | 65.1 | Hospital |
| | 68 | Nursing homes |
| **Educational Services** | 69.1 | Religious activities |
| | 71 | Cultural activities (including churches) |
| **Cultural, Entertainment, Recreational** | | |
| - Indoor | 72 | Public assembly |
| | 72.1 | Auditoriums, concert halls |
| | 74 | Recreational activities (golf courses, riding stables, water recreation) |
| - Outdoor | | |
| | 75 | Resorts and group camps |
| | 76 | Parks |
| **Office, Commercial, Retail Services** | 52 | Retail trade - building materials, hardware and farm equipment |
| | 53 | Retail trade - general merchandise |
| | 54 | Retail trade - food |
| | 55 | Retail trade - automotive, marine craft, aircraft and accessories |
| | 56 | Retail trade - apparel and accessories |
| | 57 | Retail trade - furniture, home furnishings, and |
| | 58 | equipment |
| | 59 | Retail trade - eating and drinking |
| | 40 | establishments |
| | | Other retail trade |
| **Transportation Passenger Facilities** | 15 | |
| | | Transportation, communication and utilities |
| **Transient Lodging** | 60 | |
| | | Transient lodging |
| **Other Medical, Health, Educational** | 61 | |
| **Services** | 62 | Services |
| | 63 | Finance, insurance and real estate services |
| | 64 | Personal services |
| | 65 | Business services |
| | 35 | Repair services |
| | | Professional services |
| | | Professional, scientific and controlling instruments; photographic and optical goods; watches and clocks manufacturing |