U.S. Department of Transportation
Federal Aviation Administration

Report to Congress

Aging of Sound Insulation

Federal Aviation Administration (FAA)
Report to Congress on the Aging of Sound Insulation

TABLE OF CONTENTS:

EXECUTIVE SUMMARY 1
INTRODUCTION 2
SOUND INSULATION PROGRAM AND ELIGIBILITY CRITERIA.......... 3
EARLY AIRPORT SOUND INSULATION PROGRAMS 4
SOUND INSULATION TREATMENTS 8
DETERIORATION AND LIFESPAN OF BUILDING PRODUCTS 10
DETERIORATION OF SOUND INSULATION PROPERTIES 12
AIRPORT EXPERIENCE OF SOUND INSULATION TREATMENT ISSUES 18
FIELD ASSESSMENT OF SOUND INSULATION DEGRADATION 20
OPTIONS FOR REPAIR OR REPLACEMENT 22
CONCLUSIONS AND OPTIONS FOR CONSIDERATION 24
REFERENCES.......... 25
AIRPORT NAMES/LOCATION IDENTIFIERS.......... 27

Table 1. U.S. Airport Sound Insulation Programs……………………..……………………6
Table 2. Building Product Life Expectancy...…………………………………………..…11
Table 3. Reported Issues Related to Window and Door Treatments……………..……..13
Table 4. Cumulative Complaints Related to Quality and Workmanship…………………19

EXECUTIVE SUMMARY

Congressional Language (House Report 115-237):

> Noise insulation — The Committee is concerned that federally funded sound insulation installed to mitigate airport noise is aging. The Committee directs the FAA to report to the Committee, not later than 180 days after the enactment of this Act, on the issues associated with aging sound insulation. The report should focus on sound insulation installed prior to 2007, examine the effective lifespan of common sound insulation including window and door upgrades, weatherstripping, and other sound mitigation treatments, and should include recommendations for the replacement of sound insulation that has exceeded its effective lifespan.

House Report 115-237 accompanying the Consolidated Appropriations Act, 2018 (Pub. L. 115-141) requests the Federal Aviation Administration (FAA) to report on the issues associated with aging sound insulation that was installed to mitigate airport noise. Over 143,000 residences have benefitted from the FAA's Residential Sound Insulation Program since the early 1980s. Residential sound insulation relies primarily on replacement of windows and doors.

This report draws heavily from the following FAA-funded research work through the Transportation Research Board's (TRB) Airport Cooperative Research Program (ACRP):

- ACRP Final Report 02-31, "Assessment of Sound Insulation Treatments," published September 2013; and
- ACRP Report 105, "Guidelines for Ensuring Longevity in Airport Sound Insulation Programs," published in 2014.

That research identifies factors that can affect the long-term effectiveness of sound insulation, including:

- Specific products (windows and doors) used and their acoustical properties;
- Installation and the quality and variation of workmanship of installers;
- Product deterioration over time; and
- Lack of homeowner maintenance.

The ACRP research examined a range of airport programs to evaluate homeowner complaints related to quality of products and workmanship and potential decrease in sound attenuation properties:

- Tier 1 Programs: Nine programs that have continued for at least 20 years and began before the early 1990s.

- Tier 2 Programs: Eleven programs implemented after the "early" period and continuing for a minimum of 10 years and insulating more than 500 dwellings.

Based on information from airport representatives for these programs, only a small number of programs have received complaints from homeowners specifically related to acoustic performance. However, several programs have received complaints on products (windows difficult to open, delaminated doors, etc.), which have been addressed by referring the homeowners back to the manufacturer for advice on methods of repair.

The ACRP research included acoustical testing on 23 homes that were insulated in the early years at two major airports (Boston Logan International and Los Angeles International). The majority of tested rooms did not show any noticeable decline in current measured noise reduction compared to the post-construction testing. No widespread deterioration of the sound insulation products was found as a result of the testing. Where there were instances of measurable, but not significant, effects on acoustical performance, the effects were attributed to cases of extreme neglect, extreme weathering, or possibly poor installation.

In summary, there have been few homeowner complaints noted relative to sound insulation once installed. Research into this issue found that deterioration in performance was most often the result of homeowner modifications, poor maintenance, extreme weathering, and only in some cases poor installation, and not due to deterioration in the products themselves. FAA considers sound insulation to be a one-time mitigation. Any "recommendations for the replacement of sound insulation that has exceeded its effective lifespan" would require modifications to the existing program criteria. Modification of FAA sound insulation program criteria would require a more systematic study of cost and benefit. No studies have evaluated the cost to replace aging sound insulation. However, based on this work the FAA does not believe there is evidence concluding that aging sound insulation has lost its effectiveness. Consequently, we do not believe there is justification for further study.

INTRODUCTION

It has now been 50 years since the first residential sound insulation project was successfully demonstrated in the United States as a means of reducing aircraft noise impact in communities near airports. At that time, sound insulation was not considered a cost-effective mitigation measure due to the very high noise levels aircraft of this period produced and, hence, the requirement for very high values of noise decibel reduction. The subsequent phase-out of these early, noisy jets in the 1970s and 1980s, and the corresponding reduction in aircraft noise levels, improved the cost-effectiveness of sound insulation as a noise mitigation measure, and, coupled with the availability of Federal funding in the early 1980s, led to the implementation of home sound insulation programs around most large and many medium and small airports.

In the early days of airport sound insulation programs, acoustical products were hard to find, and those that were available were designed primarily for commercial applications. Furthermore, even with the best products specified and purchased, the results were only as effective as the method of installation and contractor experience with sound insulation products, which was admittedly limited. Over the intervening years, as sound insulation programs progressed and became more numerous, manufacturers responded to market needs with more effective products, which together with increased contractor experience resolved many of the initial insulation short comings. The question that remains is whether the acoustic performance achieved in the early noise mitigation materials still provides the same noise reduction as when first installed.

Consequently, the FAA funded formal research into the issue of the longevity of airport sound programs. This took the form of the TRB's ACRP Final Report 02-31 and ACRP Report 105.

Prior to the 2013 ACRP research on sound insulation treatments, a few homeowners provided anecdotal and nonscientific reports that the acoustical performance of treatments applied in early programs had deteriorated over time. Specifically, there were reports of defects in some homes adjacent to the Boston Logan International Airport that had been treated in the early years of the program. A few other reports of deterioration were reported elsewhere, but there has been no evidence of any degradation in acoustic performance.

SOUND INSULATION PROGRAM AND ELIGIBILITY CRITERIA

Sound insulation is one of a number of voluntary measures an airport sponsor (owner) can take to mitigate noise exposure around an airport. When conducted according to certain criteria (described below), residential sound insulation programs may be eligible for reimbursement from the FAA's Airport Improvement Program (AIP), as well as the Passenger Facility Charge (PFC) Program. As of September 2019, the FAA has funded over $6.91 billion on sound insulation programs through the AIP grant program and has approved $4.4 billion through the PFC program. Through these programs, over 143,000 homes have been sound insulated, as well as other noise sensitive locations such as schools and churches. The costs for sound insulation at a typical single-family home can run from $15,000 to $65,000 per residence (and higher), along with up to $1,800 per residence for testing of noise levels.[1]

The airport sponsor conducts residential sound insulation programs, but the criteria are based on the following FAA guidance documents:

- FAA Order 5100.38D, Airport Improvement Program Handbook;
- FAA Order 5500.1, Passenger Facility Charge;
- FAA Advisory Circular 150/5020-1, Noise Control and Compatibility Planning for Airports; and
- Final Policy on Part 150 Approval of Noise Mitigation Measures: Effect on the Use of Federal Grants for Noise Mitigation Projects. Federal Register, Volume 63, pages 16409-16414, April 3, 1998.

Although the initial cost of the program may be eligible for reimbursement from AIP or the PFC Program, the replacement of sound insulation materials is treated differently under these programs. Per the AIP handbook, funding for the replacement of residential sound insulation program (RSIP) materials is not eligible through AIP entitlement or discretionary grants. In addition, the replacement is not eligible for PFC support. This is because both the AIP and PFC

[1] These figures are based on a nationwide survey of sound insulation programs by the FAA in 2014.

programs are based on an underlying premise that they cannot pay for the same work twice and cannot be used to replace defective materials.

In 1986, the FAA issued criteria for residences to be eligible for participation in a federally funded airport sound insulation program (FAA 1986), namely that:

"The structure must be located within a 65 yearly day-night average sound level (Ldn) (now DNL) contour."

Given this criterion, it was further stipulated that:

"A 45 Ldn (DNL) noise level within the major habitable rooms of a dwelling is considered the reasonable design objective for selecting noise attenuation measures."

Based on these guidelines, eligibility for participation in a federally funded sound insulation program is based on whether a residence is inside or outside the approved day/night average sound level (DNL) 65 decibel (dB) noise contour. Those within the contour were considered eligible; those outside were not, with some minor exceptions.[2] Moreover, the 45 Ldn (DNL) interior criteria is used as an objective for selecting noise attenuation measures. This criterion was further clarified in 2012 when the FAA released Program Guidance Letter 12-09 reconfirming the two-step requirement for AIP eligibility and justification requirements for noise insulation projects (e.g., (1) location within the DNL 65 dB contour and (2) 45 DNL or greater average interior sound level).

In September 2014, the FAA's Office of Airport Planning and Programming (APP) released an updated version of the AIP handbook (FAA 2014) confirming that the eligibility criteria include a two-step process, prescribing that structures must be located within the current or forecast DNL 65 noise contour and that current interior noise levels must be DNL 45 or greater.

The FAA clarified guidelines for residential sound insulation programs and the associated noise criteria in the 2014 AIP handbook.

EARLY AIRPORT SOUND INSULATION PROGRAMS[3]

Most large and many medium and small airports in the United States implemented sound insulation programs to provide a measure of protection from aircraft noise. It is useful to describe some of the earlier programs, many of them pilot programs, conducted in the early to late 1980s to understand the different approaches and the varying interpretations of the FAA's guidance documents.

It was not until the late 1960s, when the problems of aircraft noise were being addressed by California's issuance of airport noise standards, that the first major sound insulation program was

[2]When a noise contour cuts across a neighborhood, title 23 Code of Federal Regulations, part 150, allows for a degree of "block rounding" to include residences that are on or very near the edge of eligibility.
[3]ACRP Final Report 02-31, September 2013, "Assessment of Sound Insulation Treatments."

conducted in the United States at Los Angeles International Airport. This was a demonstration program conducted in 1969 on 20 single-family homes to assess the technical and economic feasibility of sound insulation as a noise mitigation measure (Wyle 1970). Technically, it was a success, but the costs were considered unacceptably high. Furthermore, even though significant increases in noise reduction were demonstrated, the very high aircraft noise levels in those years meant that interior levels were still unacceptably high.

Apart from school sound insulation programs near major airports, there was little additional implementation of sound insulation programs in the United States in the 1970s.

Following the availability of AIP funding in the early 1980s, several airports initiated pilot programs designed to test different methods of sound insulation and to establish details of project management. Subsequently, programs were implemented at most large and many medium and small airports. Table 1 shows the chronology of these programs together with the approximate number of dwelling units completed.

Los Angeles International Airport (LAX). LAX was one of the first airports to initiate a demonstration program on 20 homes in 1983. The merits of the project were demonstrated by "before and after" comparisons of interior noise levels and by the residents' responses to an opinion survey. A federally funded program was started in 1984 and continued until 2012, although programs in neighbouring cities are still in progress.

City of Inglewood, California. In 1982, as an element to the city's Urban Noise and Community Revitalization Project, the city of Inglewood performed a study to estimate the minimum costs to achieve satisfactory dwelling sound insulation against aircraft noise produced by landing operations to LAX. In 1995, the airport initiated a federally-funded program.

Table 1. U.S. Airport Sound Insulation Programs

"Total" column is an estimate of households insulated.
Shaded area refers to timeline of sound insulation program for the airport.

Airport	1970	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
ABE																											362
ANC																											163
ATL																											9500
BNA																											2500
BOS																											12000
BUR																											1800
BWI																											600
CLE																											3000
CLT																											1000
CVG																											555
DTW																											3000
EYW																											250
FAT																											800
GRR																											1
IND																											350
LAX																											10000
MCO																											24
MDW																											4000
MHT																											1100
MKE																											1477
MSP																											7000
MSY																											350
OAK																											558
ONT																											1050
ORD																											6500
PBI																											339
PDX																											33
PHX																											1500
PIT																											359
PVD																											1534
RNO																											3000
SAN																											600
SAT																											200
SEA																											9300
SFO																											14000
SJC																											2600
SNA																											382
STL																											700
SYR																											1070
TOL																											346
TUL																											1000
TUS																											1000

Norman Y. Mineta San Jose International Airport (SJC). In 1982, SJC implemented a pilot sound insulation project to assess the costs and feasibility of noise mitigation. The airport selected 10 dwellings covering a range of noise exposure zones from DNL 65 to 75 dB (Hogan 1983). A design objective based on single-event criteria was considered but rejected as too difficult and expensive to achieve, and so an interior goal of 45 DNL was established. However, it would be over a decade before the airport implemented a large-scale program.

Between 1983 and 1987, other airports conducted pilot residential programs of varying sizes with the goal of providing design and procedural guidelines for larger programs in anticipation of future FAA AIP grants.

General Edward Lawrence Logan International Airport (BOS). In 1985, the Massachusetts Port Authority (Massport) completed a residential sound insulation pilot project in four homes in East Boston and Winthrop (Stiffler 1986). The homes were of construction typical of their neighborhoods and exposed to various types of aircraft noise. The airport installed the acoustical treatments on existing windows and doors and ceilings achieving increases in noise reduction of about 10 dB (Rosenberg 1993). In high noise areas, Massport implemented a room of preference option where extra measures were taken for inner walls and ceilings to achieve an additional 8 to 10 dB of noise reduction.

Hartsfield-Jackson Atlanta International Airport (ATL). In 1985, ATL initiated a program to soundproof all owner-occupied, single-family residences within the DNL 65 dB noise contour. The treatments were limited to the installation of storm windows, solid-core and storm doors, weatherstripping and sealing, insulation, and air conditioning.

Minneapolis-St. Paul International/Wold-Chamberlain Airport (MSP). The Metropolitan Airports Commission conducted a pilot project in 1985 to assess the feasibility and costs of sound insulation. Two levels of treatment were performed: 1) a low-cost program to include air sealing and vent baffling (10 houses), and 2) a program to include insulation, air conditioning, and window/door replacement (6 houses). The net measured improvements were reductions in measured noise of 4 dB and 12 dB, respectively.

Seattle-Tacoma International Airport (SEA). The Port of Seattle initiated a pilot sound insulation study in 1985 as part of its Noise Remedy Program to abate and mitigate aircraft noise effects (Wyle 1987). Acoustical treatments were applied to 21 dwellings in a range of noise exposures from DNL 72 to 79 dB. The design objectives were: 1) achieving an interior 45 DNL in all major rooms, and 2) where practical and economically feasible, achieving an interior 65 dB single event level (SEL)[4] in living rooms and 60 dB SEL in bedrooms.

San Francisco International Airport (SFO). The city and county of San Francisco completed a Part 150 Noise Compatibility Program in 1983 and initiated early sound insulation projects in South San Francisco (Earth Metrics 1986) and in San Bruno (Wyle 1988a). In San Bruno, 48 dwellings in the Community Noise Equivalent Level (CNEL) 70 to 75 noise contour received acoustically rated windows and doors, the addition of secondary sliding glass doors, and the

[4]In the early years, there was experimentation on the most appropriate metric to use to describe interior noise levels.

addition of attic insulation and attic vent baffles. Measurements in 10 control homes indicated the project goal of an interior CNEL 45 was achieved in all rooms of the dwellings.

Baltimore/Washington International Thurgood Marshall Airport (BWI). In 1987, the Maryland Aviation Administration sponsored a residential sound insulation pilot program for 17 dwellings to determine the feasibility and associated costs of reducing aircraft noise intrusion in residential dwellings (Stusnick 1988). Dwellings within BWI's DNL 65 dB noise contour were selected for modifications. The modifications included replacement of windows and doors, addition of gypsum board to walls and ceilings, and installation of new heating, ventilating, and air-conditioning systems. The sound insulation modifications resulted in an average increase in noise reduction of 8 dB. In the subsequent expansion of the program, the FAA adopted a 5 dB noise level reduction design goal in FAA Order 5100.38A (FAA 1989).

These airports eventually expanded all of these pilot projects into large-scale projects lasting many years and sound insulating thousands of dwellings. Other large airports also initiated noise mitigation programs in the 1990s and 2000s.

SOUND INSULATION TREATMENTS[5]

The goal of residential sound insulation programs eligible for FAA funding is to ensure noise compatibility by modifying construction elements of each dwelling to provide an interior noise environment at or below 45 DNL (CNEL in California) due to aircraft noise. A secondary goal is to design the construction modifications to achieve a minimum of 5 dB improvement in the interior noise level (see AIP handbook). Dwellings inside the FAA-approved DNL 65 dB contour are eligible for consideration of residential sound insulation programs (see Table 1, 14 CFR Part 150, Appendix A).

The sound insulation of buildings is achieved by reducing sound transmission from the exterior into the interior space. This is accomplished through retrofits of existing products or replacement with new acoustically rated products and enhancements to existing construction. The main construction elements requiring replacement include windows and doors. Other elements needing modification to seal or baffle air and noise gaps and cracks include, but are not limited to, exhaust vents, fireplaces, mail slots and similar openings. Thermal insulation is often added in attic spaces to absorb noise penetrating this space prior to transmission into habitable areas.

In high noise zones, exterior wall or ceiling/roof modifications may be utilized and were in the early years. These include the insertion of wall cavity insulation and/or additional layers of interior gypsum wallboard or a secondary interior wall or exterior roof member. Sometimes layers of gypsum board may be added to the ceiling. Additionally, since sound insulation is not effective if windows are not kept closed, ventilation is provided to ensure proper air exchange while keeping windows closed.

[5]See ACRP Final Report 02-31, "Assessment of Sound Insulation Treatments," September 2013; and ACRP Report 105, "Guidelines for Ensuring Longevity in Airport Sound Insulation Programs," 2014.

In the majority of programs, windows, doors, and vents are the weakest acoustical points both before and after treatments are applied. Windows and doors are the products most likely to suffer from design defects, incorrect installation, and normal deterioration over time. There are three principal ways to treat windows and doors:

1. Repair and upgrade existing windows with new glass, weatherstripping, caulking, etc. Replace and upgrade existing doors with solid-core doors, weatherstripping, caulking, etc.;
2. Adding secondary storm products to the existing openings; and
3. Replace the product with acoustically rated products.

While it is possible to achieve noise reduction by refurbishing existing windows and doors, most programs now choose complete replacement of fenestration (doors and windows) with acoustically rated products.

In the early days of airport sound insulation programs, acoustical products were hard to find,[6] and those that were available were designed primarily for commercial applications. As a result, early programs used a combination wood or aluminum prime window with an aluminum storm or double aluminum-frame windows. The first acoustic windows were aluminum, which tended to be somewhat flimsy, and were subject to misalignment as screws were tightened during installation. Some experienced failure of the thermal break between the glass panels, which provided the mechanical isolation necessary to achieve the higher noise attenuation. Other problems included condensation, broken seals, and poor weatherstripping.

As sound insulation programs progressed and became more numerous, the manufacturers responded to market needs, and many of these problems were resolved. However, the major advance in window design was the introduction of vinyl windows in the late 1980s. At first, some designers and contractors did not immediately accept the new products, partly because the first versions were much thicker than existing products they had been using and partly because they were unsure of whether vinyl windows would be acceptable to the public.

Similar to windows, doors are a weak link in sound insulation performance. Almost all typical residential doors require replacement or modification to meet the sound insulation goals of a project. These modifications include repair or replacement of the existing door by adding secondary acoustical storm doors (not a popular treatment in California) or replacing the existing doors with specially designed, high sound transmission class (STC) rated acoustical doors.

There are three basic primary entrance door types used in sound insulation projects: steel/metal, flush wood, and wood panel (stile and rail). Fiberglass doors, while increasingly popular in home renovations, do not currently provide the necessary acoustical performance criteria for sound insulation programs. While stand-alone acoustical doors without glazing are offered in most programs, some programs also provide custom quality doors with insulated glass installed with secondary storm doors. Only a handful of manufacturers make STC-rated flush doors that have a high enough STC rating to be used without a secondary door.

[6]ACRP Final Report 02-31, September 2013, Assessment of Sound Insulation Treatments.

The acoustic doors used in early programs also did not perform well. The basic construction has improved over the years so that doors became sturdier and less subject to delamination, and advances have been made in the edge seals and in installation methods. The internal drop seals at the door threshold never worked as well as intended and were prone to misalignment. These were subsequently replaced with improved weatherstripping and an auxiliary sweep. Doors used to be replaced within the existing frame, or the door and frame were installed separately. Today, programs use prehung doors complete with a new threshold.

In the early years, doors were heavy and fitted with inappropriate seals, and in some instances, provided STC ratings sufficient for sound attenuation. Modern doors are manufactured with different core materials and are lighter in weight. Sliding glass doors also could not provide the necessary STC rating and programs opted to specify combination of primary and secondary sliding glass doors, which were inconvenient to operate. Modern sliding glass doors have been designed for high STC ratings.

Along with improvements in acoustic products, the installation methods have improved due to introducing more rigorous training for contractors and more detailed inspection procedures throughout construction. Whereas contractors in early programs tended to regard insulation installation jobs to be just the same as any other house upgrade, they now realize that sound insulation construction requires much more attention to detail. Furthermore, the procedures for addressing existing building code violations have become more rigorous in deciding eligibility for sound insulation treatment.

DETERIORATION AND LIFESPAN OF BUILDING PRODUCTS

Deterioration of building structures in general is related to durability. Durability of various building components, particularly windows or doors, is defined as the ability of a material, product, or building to maintain its intended function for its intended life expectancy with intended levels of maintenance in intended conditions of use (NAHB 2002). The manner in which materials and buildings degrade over time depends on their physical makeup, how they were installed, and the environmental conditions to which they are subjected. The Durability by Design Guide (NAHB 2002,) lists factors affecting building durability, such as moisture, sunlight (UV radiation), temperature, chemicals, insects, fungi, natural hazards, and wear and tear. Most notable of these factors are moisture, UV radiation from sunlight, and temperature. Other problems, such as mold and indoor air quality, are also related to moisture.

According to various industry surveys summarized in the NAHB Design Guide, windows and doors are among the major commonly reported durability issues in new construction, frequency and cost of homeowner warranty claims, and overall expenditures for repairs, maintenance, and replacement. Air and water leakage and glass fogs and frosts are the main performance problems, while poor weatherstripping, checking and splitting of panels, and swelling are widespread problem areas for exterior doors.

Durability and service life expectancy of windows depends a large degree on the window framing material and assembly details (Vigener 2010). Wood, vinyl, and fiberglass are currently the most widely used window frame materials in residential construction. Steel frames are less common.

Wood frames are prone to separation of frame joints from moisture and thermal, structural, and transportation movements. Wood frames are also more likely to decay from prolonged contact with moisture unless they are pressure treated and properly coated. Many new wood windows are protected by a durable exterior finish or cladding that prevents moisture from forming underneath (EWCG 2011).

Aluminum frames are strong and inherently corrosion resistant in most environments if anodized and properly sealed or painted; however, they readily conduct heat. Condensation and even frost can be an issue with aluminum windows. Thermal breaks reduce conduction and improve condensation resistance; however, the durability of thermal breaks varies by type and quality (EWCG 2011).

Vinyl window frames provide better energy performance than aluminum frames due to lower thermal conductivity, and vinyl frames offer welded components that seal the joinery. Vinyl window frames provide good moisture resistance and are low maintenance, but they tend to expand or contract with changes in temperature. Recent designs have improved dimensional stability and resistance to ultraviolet radiation and temperature extremes (EWCG 2011).

The service life or life expectancy of building components is reported in numerous publications based on surveys, but can vary significantly between climatic regions and among building types. A summary of this survey data, together with information from the manufacturers, is provided in Table 2.

Table 2. Building Product Life Expectancy[7]

Building Material	**Replacement Cycle (Years)**
Insulating Glass Unit [8]	10+
Vinyl windows	20-40
Aluminum windows	20+
Wood Windows	30+
Aluminum doors	25
Acoustical wood doors	20+
Caulking/weatherstripping	10-15
Hardware	10
Sealant	7-10
Insulation	30

[7]This list should be used only as a general guideline as life expectancy varies with usage, weather, installation, maintenance, and quality of materials.

[8]An Insulating Glass Unit (IGU) is made up of a sandwich type construction consisting of two (or more) panes of glass with a gas-filled gap that is sealed around the edges. Manufacturers note that the seals in IGUs are the most likely part to fail, but if they do fail, it's usually within the first few years. Therefore, most failures are covered by the manufacturer's warranty. Other than that, a good estimate for their lifespan is 20 years.

DETERIORATION OF SOUND INSULATION PROPERTIES[9]

All building components and products deteriorate over time due to normal "wear and tear" and weather effects, but not usually to the extent that their acoustic performance is noticeably reduced. Door and window manufacturers provide warranties of (typically) 5 and 10 years respectively for their products; however, it is not only the products that can deteriorate. Poor workmanship and incorrect installation procedures can lead to problems, such as caulking and filling materials contracting with exposure to adverse weather conditions. These types of problems are normally identified during construction inspection, but can remain hidden and can go unnoticed at the time of installation only becoming apparent at a later date.

Factors that can determine the long-term effectiveness of sound insulation modifications can be summarized as follows:

- The specific acoustical products used in a particular program or a phase of the program;
- Installation techniques used by the contractor for acoustical products, such as the use and quality of insulation and caulking materials, etc.;
- Quality of workmanship of the installers and effectiveness of the contractors' quality control procedures;
- Variations in the workmanship of general contractors performing construction of different bid groups of homes within the program;
- Applying treatments to a home to improve the sound insulation properties requires much more careful workmanship than contractors are generally used to providing; and
- The resulting sound insulation provided at each dwelling may depreciate over time due to the lack of homeowner maintenance causing product deterioration.

Reported Issues with Sound Insulation Products

Table 3 presents a listing of the most common reported issues that are related to the performance of doors and windows and the corrective actions adopted by airport programs and manufacturers. Many of these issues were identified during or soon after installation of the products or were referred to manufacturers for repair or replacement. Some have been referred back to the homeowners as being their responsibility for maintenance. The remaining were resolved as technology evolved.

[9]See ACRP Final Report 02-31, "Assessment of Sound Insulation Treatments," September 2013; and ACRP Report 105, "Guidelines for Ensuring Longevity in Airport Sound Insulation Programs," 2014.

Table 3. Reported Issues Related to Window and Door Treatments

Delamination of doors	Description	**Description:** Delamination of the doors was one of the main issues from the early years of sound insulation programs and continues to cause problems. Acoustical wood doors contain different layers of insulation material and veneer bonded together. This combination is susceptible to moisture, which can cause the door to delaminate. Delamination is not exclusive to wood doors and has been experienced with aluminum metal prime doors where there is a full glass storm door over a dark-colored door in full sun exposure.
	Resolution	**Resolution:** • Include finishing instructions for the door leaf in the technical specification, including the number of required paint or varnish coats, the field condition under which the door finish is applied, and/or a requirement to finish all edges and holes/cuts. • Require preprimed doors or application of sealer/primer and first coat in a warehouse in a dry, controlled environment. • Have seasoned construction managers inspect the door finish, especially at the door edges and holes cut through the door for hardware. As technology has advanced, construction of the door core and the way it is bonded to the door skin has improved allowing door manufacturers to increase the warranty period from 1 or 2 years to 5 years.
Warpage of the entire door panel	Description	**Description:** About 25 percent of all complaints about doors are related to door warpage. Warpage can occur due to the condition of the wood products; the manufacturing process; environmental conditions at the site, including temperature fluctuation and moisture; the environmental conditions of the warehouse where the door was stored before installation; faulty finishing; and/or faulty installation.
	Resolution	**Resolution:** • Advances in technology to design an improved core. • Improvements in the manufacturing process for attachment of the door skin to door core. • Improvement in technical specifications to include finishing instructions. • Specification of how doors are to be stored in the warehouse. Manufacturers routinely honor the warranty of the door if warpage occurs during the warranty period if the other requirements of the warranty language are met.
Automatic door bottom seals	Description	**Description:** Automatic bottom seals were a continual problem in early sound insulation programs. They required regular maintenance or they would lose their tightness, alignment, and/or would break entirely.
	Resolution	**Resolution:** Most programs have replaced automatic door bottom seals with alternative in-place seals.

Difficulties operating acoustical doors	**Description:** Early acoustical doors were heavy and difficult to operate.
	Resolution: Improvements in the design and manufacture of wood doors. The changes in how the core is manufactured and the material used in the core have resulted in much lighter doors with the same or better acoustical performance. The lighter doors also are much easier to install and therefore minimize the potential issues related to installation or future sagging of the door.
Difficulties installing the door leaf within the existing door frame	**Description:** During the early years of sound insulation programs, only door leaves were replaced. It was often difficult to fit the new door within the existing frame or to add the necessary air/acoustic seals.
	Resolution: Prehung doors are now specified, including both the door leaf and door frame. The new details consider kerfed-in seals if new frames are not specified.
S-88 smoke seals or bulb seals peeled off easily	**Description:** During the early years, programs received complaints regarding the seal peeling off and leaving a gap for noise to penetrate the dwelling units.
	Resolution: Many programs discontinued the use of the seal and replaced it with a combination of rigid seals and kerfed-in seals. This remedy, along with the issues mentioned in the previous item, required specifying new doorframes that could accommodate the kerfed-in seals. The use of S-88 (smoke seals) is limited to garage access doors for meeting the requirements of building codes.
Misalignment of aluminum windows	**Description:** Early acoustic windows were aluminum, tended to be somewhat flimsy, and were subject to misalignment as screws were tightened during installation.
	Resolution: Specifications included requirements for aluminum frame alloy and/or thickness.
Improper operation of hardware	**Description:** Improper operation of hardware interfering with closure of doors and windows.
	Resolution: There have been numerous advancements in hardware technology, and manufacturers dealt with this issue on the spot or incorporated changes into their manufacturing process, quality control, and/or design to minimize problems related to hardware malfunction.
Weatherstrip deterioration	**Description:** Weatherstrips are vulnerable to wear and tear and need regular maintenance.
	Resolution: Due to improvements in technology, manufacturers now use more durable weatherstrips in acoustical window products.

Deterioration of caulking	**Description:** Due to structure settlement or aging, the caulking surrounding building components may crack or deteriorate. This may result in air and sound gaps or water intrusion and deterioration of frames and other construction, creating other sound transmission paths.
	Resolution: It is the responsibility of the homeowner to maintain sound insulation products and installation.
Condensation	**Description:** Condensation in double window assemblies and insulated glass units.
	Resolution: Improved edge sealing is now used to exclude air and moisture infiltration.
Sagging of casement windows	**Description:** During the early years, sagging in casement windows created problems with closing the windows and loss of acoustical effectiveness. Although sagging is inherent in this type of the window because of its weight, there were two other major contributors to this issue: • Windows were specified without consideration of the maximum size set by the manufacturers. The limits set for the size of these windows were too high, contributing to additional weight and, as a result, sagging. • Faulty installation also contributed to the sagging. The windows were installed without proper connections to the structure or adequate support at the sill.
	Resolution: Specifying solid continuous blocking along the whole length of the window to completely support the window at its sill. • Ensuring that the window is securely attached to the structure at the window jambs according to manufacturers' installation instructions. • Setting size limitations for casement windows to deal with window weight.
Dirt buildup on sliding tracks	**Description:** Dirt buildup on sliding tracks of horizontal slider windows and sliding glass doors can cause increasingly difficult operation and eventual failure of hardware.
	Resolution: Bringing the issue to the owners' attention during the design or construction phases so that they can routinely clean the tracks. Provision of a design (by one window manufacturer) where the roller sits on a rail rather than rolling on a flat surface of the window track alleviating issues related to the roller and dirt buildup in the track.
Thermal break failure in some aluminum windows	**Description:** The material used to create the thermal break of one window manufacturer's design deteriorated over time and broke down in climates with weather extremes leaving gaps in the gasket that water could leak through. In wet weather conditions, water would run down the glass, into the gaps in the deteriorated gasket, and into the wall.
	Resolution: Following lab reports, site visits of affected facilities and communication with the window manufacturer, it was decided that that type of window would not be used in sound insulation projects in colder climates.

Incorrect maximum sizes	**Description:** Incorrect maximum sizes for 3-lite sliders, which caused the frames to deflect.
	Resolution: New windows of a different configuration had to be installed.
Incorrect glass thickness	**Description:** Incorrect glass thickness was detected in windows where ⅛-inch glass was substituted for ¼-inch glass in the full-lite, self-storing, storm doors.
	Resolution: Manufacturer replaced storm doors.
Corrosion of aluminum windows	**Description:** In close proximity to salt water, aluminum frames showed corrosion due to salt-laden air.
	Resolution: With advances in technology, more effective and longer lasting coatings have become available to manufacturers, who have taken advantage of the technology to improve the longevity of their products.
R-values of thermal insulation deteriorating over time due to settling	**Description:** The compaction of loose cellulose fill reduces the volume of air spaces within the fiber and its insulation value.
	Resolution: Some programs use fiberglass batt insulation in ceilings whenever possible.
Double sliding glass doors	**Description:** Double sliding glass doors were massive and difficult to open.
	Resolution: STC-rated sliding glass doors have been introduced into projects. This advancement eliminated the necessity of adding storm doors to existing sliding glass doors.

The best products can be specified and purchased, but they are only as effective as the method of installation. Through experience with early sound insulation programs, installation methods improved by introducing more rigorous training for contractors and more detailed inspection procedures throughout construction. Whereas contractors in early programs tended to regard jobs to be just the same as any other house upgrade, they now realize that sound insulation construction requires much more attention to detail. Furthermore, the procedures for addressing existing code violations became more rigorous in deciding eligibility for sound insulation treatment.

From the life expectancy assessments in the early residential sound insulation programs implemented between 1985 and 1995, windows and doors may have reached their upper limit of lifespan within the 2005-2015 timeframe. Based on this, the few anecdotal reports identified regarding deterioration in the acoustical performance of windows from earlier programs may have resulted from “normal” conclusion of their service life. In the case of acoustical treatments, this could lead to either real or perceived defects in their sound insulation performance.

There have been isolated reports of defects in doors and windows related to an early program conducted by Massport near Boston Logan International Airport. These anecdotal claims suggest the acoustical performance of treatments applied in earlier programs might have deteriorated over time (Massaro 2007). The treatment in this program consisted of aluminum storm windows, replacement of prime doors within the existing frame, and the addition of an adjoining storm door. In the years since these treatments were applied, homeowners have complained of drafts and increased noise. In some cases, homeowners have applied tape to overcome these problems. Inspection has shown excessively large gaps between window sashes and jamb liners, thermal seals broken with resulting condensation fog, nonexistent perimeter seals, and stress cracks in the window glazing. Over time, noise paths and drafts have increased due to increasing size of gaps between window sashes and jamb liners.

Homeowners have also complained about windows slamming due to loose and broken balances and of difficulty opening windows due to broken clips, balancers, or wheels. Massport does not consider this to be an acoustic failure, but believes it is related to a substandard product and the manufacturer's failure to address warranty issues (Massaro 2007). Overall, it would appear that the problems encountered in those early years at Massport could be due to a combination of poor product quality control coupled with inadequate inspection of installation methods. The manufacturer of the windows believes many issues can be attributed to homeowners improperly finishing the window, including caulking the interior of the window. Also, some homeowners failed to finish and/or seal the wood interior. This condition, in conjunction with condensation, would cause the wood to degrade.

Reports of deterioration were also noted in the early Minneapolis-St. Paul sound insulation program. In the Minneapolis-St. Paul case, wood windows were used, and there have been a few cases of wood rot and condensation problems, and no reports of acoustic deterioration.

Homeowner Maintenance of Sound Insulation Products

Manufacturers provide care and maintenance manuals designed to inform building owners on how to properly care for the acoustical products they receive. Failure to properly maintain these products will generally reduce the useful life and may void the manufacturer's warranty. Proper maintenance and care for the installed products are key factors in the durability of acoustical performance of sound insulation products.

Wood products and sealants are the most vulnerable materials installed, and lack of proper maintenance will contribute to failure of windows and doors. Wood products require repainting or refinishing regularly to prevent moisture or ultraviolet damage and wear.

As discussed in previous sections, durability based on the interdependency of systems may become apparent long after the construction is completed. For example, programs can specify and install the most expensive acoustically rated windows, but the homeowner's neglect in fixing or replacing cracked sealants and caulk can result in moisture penetrating and becoming trapped around the window. This can, in turn, result in damage to window framing and eventually create a path for noise to penetrate the building.

Malfunction of window or door hardware is one of the reported reasons for failure of windows and doors in their sound insulation performance. Many homeowners indicated poor window functionality, such as difficulties with opening and closing. This is often the result of allowing dirt to accumulate in the widow tracks and can lead to the use of excessive force and hardware breakage. Mechanical deterioration of windows and doors does not necessarily translate into deficient acoustical performance.

AIRPORT EXPERIENCE OF SOUND INSULATION TREATMENT ISSUES

In order to determine the extent of any deterioration in acoustic effectiveness of sound insulation treatments, ACRP Final Report 02-31 conducted a survey to gather information from a range of airport programs. Programs in two tiers were selected for data gathering, namely:

- Tier 1—to identify product quality control and workmanship issues in earlier programs (at least 20 years old); and
- Tier 2—to identify product quality control and workmanship issues in later programs (less than 20 years old).

Programs in each tier were selected to cover a wide range of climate conditions.

Tier 1 Programs: Defined as early programs that have continued for at least 20 years. The term "early program" was defined as one that was started before the early 1990s. By the early 1990s, considerable experience had been gained by consultants, product manufacturers, and contractors. Tier 1 programs were in place before vinyl windows became the most commonly used replacements for existing windows. Tier 1 programs provide data to cover the entire history of sound insulation and thereby yield a complete chronology of the changes in methods, procedures, and products, as well as providing data on any deterioration of products over an extended period.

Applying these criteria to the airports listed in Table 1 resulted in nine programs:

- Atlanta
- Baltimore
- Boston
- Los Angeles
- Minneapolis-St. Paul
- Ontario
- Seattle
- San Francisco
- Tucson

The selected list includes all the early programs with a wide range of climatic conditions. In total, they cover over 50 percent of all homes treated in the United States to date.

Tier 2 Programs: Established programs implemented after the "early" period. Program selection for this tier included those established in the early 1990s around the time vinyl windows became available; continuing for a minimum of 10 years; and insulating more than 500 dwellings.

Including programs established in the early 1990s provides a study period long enough to experience changes and possible product deterioration. Applying the criteria to the airports listed in Table 1 resulted in 11 programs:

- Burbank
- Chicago
- Cincinnati
- Cleveland
- Fresno
- Manchester
- Pittsburgh
- Providence
- San Diego
- Reno
- San Jose

For each of these programs, the focus for data collection was limited to homeowner complaints over time related to quality of products and workmanship and potential decrease in sound attenuation properties.

Based on information from airport representatives for these programs, only a small number of programs have received complaints from homeowners specifically related to acoustic performance. Several programs have received complaints on products (windows difficult to open, delaminated doors, etc.) and to a large extent these have been addressed by referring the homeowners back to the manufacturer for advice on methods of repair.

Table 4. Cumulative Complaints Related to Quality and Workmanship

Note: This table includes both Tier 1 and Tier 2 programs

Airport	**Program Duration**	**Homeowner Issues**	**Reports of Acoustical Degradation**
Atlanta	1985 - 2000	Few complaints.	No
Baltimore/Washington	1988 - 2012	Initial condensation problems solved with air conditioner. No complaints since.	No
Boston Logan	1985 - 2009	Many complaints.	Yes
Burbank	1998 - 2014	Few complaints.	No
Chicago	1998 - present	Quality control issues with early products resolved. Off gassing of vinyl products reported.	No
Cincinnati	1996 - 2006	Issues related to window operation.	No
Cleveland	1996 - 2014	No reported issues.	No
Fresno	1995 - present	Few complaints.	No

Airport	Program Duration	Homeowner Issues	Reports of Acoustical Degradation
Los Angeles	1984 - 2014	Few complaints regarding warranty issues.	No
Manchester – Boston Regional	1995 - 2009	Few complaints. Window and door hardware failed.	No
Minneapolis – St. Paul	1992 - present	Some wood rot in early products. Complaints request advice for repair or replacement.	No
Ontario	1994 - 2012	None.	No
Pittsburgh	1996 - 2009	None.	No
Providence	1991 - present	Few complaints.	No
Reno	1995 - 2014	Homeowners noted that today's products are superior to their treatments.	No
San Diego	2000 - present	Few complaints.	No
San Jose	1998 - 2009	None.	No
San Francisco	1985 - 2014	Few complaints regarding windows cracked, IGU gas leakage. Airport evaluating a limited internally funded repair/replacement program.	Possible
Seattle	1985 - present	Inner seals of some vinyl windows failing. Homeowners requested airport action.	No
Tucson	1992 - 2012	None.	No

FIELD ASSESSMENT OF SOUND INSULATION DEGRADATION

ACRP Final Report 02-31 evaluated whether product deterioration had affected sound insulation, acoustical measurements, and architectural testing in 2012 for 28 rooms of 15 homes that were insulated in the early years of the Massport residential sound insulation program in the vicinity of Boston Logan International Airport. The goal of the acoustical testing was to obtain current room noise reduction information and then compare it to the noise reduction data obtained immediately after (postconstruction) the sound insulation was completed. The selection of houses for the retesting was made by Massport and included some with known homeowner complaints related to windows and/or doors, as well as homes in apparently good condition. The measurement program was designed to:

- Identify deterioration in acoustic performance of dwellings insulated in the early programs;
- Identify the causes for any deterioration – products, materials, installation; and
- Correlate inspection data with the acoustic measurements to identify any trends related to product deterioration, installation, or maintenance.

The same acoustic test procedure used in the original measurements (aircraft flyovers or artificial noise source) was employed in the testing. The same artificial source location and microphone locations were utilized. Every attempt was made to replicate the original test procedure as much as feasible.

In addition to the acoustic measurements, an evaluation of window and door installations in each home was conducted to determine the current condition of the installed components. This was achieved through a visual inspection of the window and door systems, as well as the adjacent systems that might affect acoustics. The inspection process focussed on the following items:

- Existing fenestration and door systems and if they were the original products installed;
- Inspection of the interior around the units for signs of damage or deterioration;
- Existing condition of systems (including function) and components (such as sealants and weatherstripping);
- Dimensional checks of the fenestration installation to verify installation was within tolerance (size, square, plumb, etc.);
- Signs of leakage/openings;
- Evaluation of components (balances, hardware, frames, glazing, gaskets, perimeter sealants, etc.) to determine general level of operational performance;
- Maintenance performed; and
- Potential cause of deteriorated system/components (damage, wear and tear, exposure, installation techniques, etc.).

The inspection data was reviewed to determine if any deterioration in acoustic performance was due to:

- Product (window, door) quality control (manufacturer);
- Poor workmanship in installation (contractor); or
- Inadequate maintenance or ill treatment (homeowner).

An analysis of the data from the Massport measurements showed that of the 28 rooms tested, only three (11 percent) showed a significant decrease in noise reduction between the original postconstruction testing and retesting. Of those three rooms, the results directly point to deteriorated acoustical performance of the windows due to improper installation, wear and tear, weathering, or inadequate maintenance. One other room did show a significant decrease in noise reduction, but the room had been modified by the homeowner. For most of the rooms, the postconstruction test data showed no noticeable decline in measured noise reduction despite the evident deterioration in the physical conditions of the product or surrounding structure. Many homeowners indicated poor window functionality - difficulties with opening, closing, cleaning, tilting, etc. However, physical or mechanical deterioration of windows and doors noted did not translate into deficient acoustical performance.

It can be concluded that no widespread deterioration of the sound insulation products was found as the result of the testing in Boston. The few cases of deficient acoustical performance that were discovered can be attributed to cases of either extreme neglect, extreme weathering, or possibly poor installation.

Similar acoustical testing was performed (in 2012) in nine homes (35 rooms) that were insulated in the Inglewood, California, 1995 residential sound insulation program in the vicinity of LAX. The original testing was conducted by simultaneously measuring the noise levels outside and inside of the house with actual aircraft flyovers. This technique was reproduced for the retesting with exterior and interior microphone locations replicated as closely as possible to their original locations. An analysis of the results showed that there was a significant decrease in noise reduction (increase in noise) in three rooms of one home. Apparently, in the intervening years alterations had been made by the homeowner that included replacing carpeting with hardwood flooring and replacing the solid core front door with a hollow acoustically nonrated door. This indicates that no major change in the sound insulation performance had occurred in eight of the homes (32 rooms) since 1995.

In summary, the retesting of 63 rooms in 24 homes at two airports showed that only seven rooms tested showed signs of acoustical deterioration, and at least four of these rooms had been modified by the homeowner after the sound insulation treatments were installed. The majority of tested rooms did not demonstrate a decline in measured noise reduction compared to the postconstruction (final) testing. The few instances that were discovered to have a less significant but finite deficiency in acoustical performance can be attributed to cases of extreme neglect, extreme weathering, or possibly poor installation. Proper maintenance of sound insulation products, similar to regular windows and doors, appears to be a key factor in sustaining acoustical performance of the products. Many homeowners indicated poor window functionality, such as difficulties with opening, closing, cleaning, etc. The testing showed that physical or mechanical deterioration of windows and doors did not necessarily translate into deficient acoustical performance.

OPTIONS FOR REPAIR OR REPLACEMENT

The ACRP Final Report 02-31 concluded that results from the noise tests conducted on 63 rooms in 23 houses at two sound insulation program sites show that there has been less deterioration in performance over the years than the research team had hypothesized. This is consistent with the lack of reported deterioration in performance obtained from the survey of U.S. programs. In most cases, any deterioration in performance is most likely to be the result of homeowner modifications, poor maintenance, extreme weathering, and only in some cases poor installation, and not due to deterioration in the products themselves.[10]

---

[10]This does not necessarily imply that there have been no problems with products or installation procedures. Many programs have reported issues related to the operation of windows and doors, but to a large extent, these were identified by the program sponsors (or their consultants) and corrected by the product manufacturers or contractors within the warranty period. Questions from homeowners after the warranty has expired are generally referred to the suppliers for advice, and in some cases, by providing helpful inputs on where replacement parts could be purchased. It is uncommon for homeowners to demand actions by the airports.

The sound insulation program is voluntary and most homeowners appear to accept that the treatments they received were a one-time only mitigation measure. It was clearly stated in the 1985 AIP handbook (FAA 1985) and subsequent updates that the responsibility for maintenance and operation of the insulation items lies with the property owner and that neither the FAA nor the airport sponsor bears any responsibility for maintenance or operation of these items. Homeowners sign contracts when receiving sound insulation agreeing to a stipulation, such as the following:

"All sound insulation materials shall become the property of the OWNER upon completion of the WORK and final inspection by the OWNER and City's Program Staff. General maintenance of doors, windows, and all other items, and their replacement beyond expiration of manufacturer's warranty shall be the responsibility of the OWNER."[11]

The latest version of the AIP Handbook issued in 2014 (FAA 2014) states that costs are prohibited for:

"Follow-on replacement of windows, doors, equipment, or any items installed for noise reduction that appear to have met their useful life. Installation of noise reduction equipment is limited to the initial installation only."

It is the responsibility of homeowners to ensure that proper maintenance is carried out on their property and on the equipment and fittings used in their home in accordance with manufacturers' recommendations. All windows and doors (regardless of whether they are acoustical or nonacoustical products) have an estimated lifespan of 20 to 25 years, and homeowners have to repair or replace them eventually. By installing new windows and doors, the sound insulation program effectively deferred the timeframe for the homeowners' normal repair or replacement cycle by 20 to 25 years.

If repair is necessary at any time, airports can and often do assist homeowners in finding replacement parts. Window and storm door glazing and operating parts can be repaired at reasonable cost provided that the frames are still in good condition, and weatherstripping can be replaced cheaply using products from local hardware suppliers.

A few homeowners claim that their treatments have deteriorated over time either in appearance or in sound insulation and that they are still impacted by aircraft noise. There can be a number of reasons why they may have this perception, including:

- If there actually has been a physical deterioration of the products installed, but not acoustical deterioration;
- If the exterior noise environment has changed (e.g., nature of airport operations or other community sources—such as highway or railroad—resulted in increased noise levels, or increased number of events);

[11]Text from the "Participant Agreement, City of Inglewood, Residential Sound Insulation Program." Emphasis included in original contracts. Similar clauses are included in the homeowner agreements for all sound insulation programs.

- If the original furnishing in rooms has changed (e.g., reduced noise absorption leads to higher interior noise levels);
- If there were subsequent modifications by homeowners; or
- If the reported degradation is from new occupants who moved from previously treated dwellings.

Representatives from Massport reported that their early program starting in the mid-80s was essentially a pilot program using the limited products and installation methods available at the time (Massaro 2007). They are proposing a federally funded modification or "return" program, which falls within the category of perfecting the flaws of early years by providing today's more acoustically perfected products of advanced durability and lifespan not available in the early years.

The proposed return program is not a proposal for a never-ending maintenance program, but would provide highly impacted areas with current advanced soundproofing methods. It would limit eligibility to those homes originally treated before acoustically rated composite windows (pre-1993) were available and which are located within the current DNL 65 dB noise contour.

In response to queries from homeowners, SFO reported that it is planning to adopt a limited program to address the issue of aging sound insulation products. At a recent meeting of the San Francisco International Airport/Community Roundtable, a plan was approved to initiate an airport-funded replacement noise abatement program where homeowners, whose homes had been treated in an earlier phase and who believed that their sound insulation had deteriorated, could apply for repair or replacement of sound insulation products. The homes of applicants would be inspected for product deterioration before being considered eligible for the program. Eligibility also would require that the home lie within the current DNL 65 dB noise contour and not exhibit any physical damage or lack of maintenance. The proposed program at SFO would cover the local cities that implemented early sound insulation programs.

CONCLUSIONS AND OPTIONS FOR CONSIDERATION

Federal funding has been available (to eligible participants) for residential sound insulation since the early 1980s. The number of people exposed to aircraft noise has significantly decreased over the years. A primary reason for this decrease is that aircraft noise levels in the 1980s, which were dominated by louder Stage 2 aircraft, have since been removed from the fleet and replaced by the much quieter Stage 3 and 4 aircraft. Even though operations may have increased, airport noise contours have shrunk significantly since the 1980s with the number of people at U.S. airports exposed to greater than DNL 65 dB reducing from 3,400,000 in 1985 to 410,000 in 2017. Now that the exterior DNL has reduced by 5 to 10 dB at many airports, the interior levels are much lower. As a result, many of the houses in early treatment programs would no longer be eligible for the program or would not be eligible for the degree of treatment they received when noise levels were much higher. Furthermore, the criteria used for eligibility in the 1980s did not always include the interior 45 DNL requirement because it was not being uniformly applied. So some of the houses treated in those years would not be eligible for sound insulation under the current guidelines.

Nevertheless, houses being treated more recently benefit from new technology that was not available in the very early years. Some homeowners who were participants in the early programs have noted that the products used in current programs are much improved over those installed in their homes in the early years.

The FAA considers sound insulation to be a one-time mitigation. Any "recommendations for the replacement of sound insulation that has exceeded its effective lifespan" would require modifications to the existing program criteria. Modification of FAA sound insulation program criteria would require a more systematic study of cost and benefit. No studies have evaluated the cost to replace aging sound insulation. However, based on this work the FAA does not believe there is evidence concluding that aging sound insulation has lost its effectiveness. Consequently, we do not believe there is justification for further study.

REFERENCES

DOT (1976). Aviation Noise Abatement Policy, United States Department of Transportation, November 1976.

DOT (1981). Airport Noise Compatibility Planning and Programs Under P.L. 91-258 and P.L. 96-193, Report of the Secretary of Transportation to the Congress, October 1981.

Earth Metrics (1986). Final Report for the Aircraft Noise Insulation Project for San Francisco International Airport: Phase one Pilot Project, FAA funded, and prepared for the city of South San Francisco, Earth Metrics, Inc., Burlingame, California, July 1986.

EWCG (2011). Select New Efficient Replacement Windows. The Efficient Windows Collaborative Guidance Center for Sustainable Building Research, Alliance to Save Energy, and Lawrence Berkeley National Laboratory, http://www.efficientwindows.org/homesexisting_guidance6.cfm, July 2011.

FAA (1977). Airport Noise Control and Land Use Compatibility Planning (ANCLUC) Under the Planning Grant Program, FAA Order No. 5900.4, September 1977.

FAA (1985). Airport Improvement Program (AIP) Handbook, Federal Aviation Administration, Order 5100.38, February 1985.

FAA (1986). Airport Improvement Program (AIP) Handbook, Federal Aviation Administration, Order 5100.38, CHG3, November 1985.

FAA (1989). Airport Improvement Program (AIP) Handbook, Federal Aviation Administration, Order 5100.38A, October 1989.

FAA (2014). Airport Improvement Program (AIP) Handbook, Federal Aviation Administration, Order 5100.38D, September 2014.

FAA (2012) Program Guidance Letter 12-09, *Eligibility and Justification Requirements for Nosie Insulation Projects*, August 17, 2012 (now cancelled).

Fazeli, F.K., and Sharp, B.H. (2013). Guidelines for Ensuring Longevity in Airport Sound Insulation Programs, ACRP Report 02-31, Transportation Research Board of the National Academies, September 2013.

Hogan, C.M. (1983). Final Report of the Pilot Noise Insulation Study, Earth Metrics Report, October 1983.

InterNACHI (2010). Estimated Life Expectancy Chart. International Association of Certified Home Inspectors, Inc. (InterNACHI), December 2010.

Kesik (2002). (Enclosure Durability. http://www.canadianarchitect.com/asf/enclosure_durability, July 2011.
Massaro, F. (2007). Modifying Old Sound Insulation Treatments, presentation at the 7th Annual Aviation Noise and Air Quality Symposium, San Diego, California, October 8-10, 2007.
Mayer, P. (2005). BLP Durability Assessment. Building LifePlans Ltd., London, July 2005
NAHB (2002). Durability by Design. A Guide for Residential Builders and Designers. National Association of Home Builders (NAHB) Research Center, Inc., U.S. Department of Housing and Urban Development (HUD), Washington, DC, May 2002.
NAHB (2007). Study of Life Expectancy of Home Components. National Association of Home Builders (NAHB)/Bank of America Home Equity. Washington, DC, February 2007.
Old (2010) Life Expectancy. The Old House Web, http://www.oldhouseweb.com/how-to-advice/life-expectancy.shtml, December 2010.
Ontario (1996). Building Element Life Expectancy Guidelines. Ontario Housing Corporation, Canada, April 1996.
Rosenberg, C. et al. (1993). Evolution of the Massport Sound Insulation Program, Proceedings of NOISE-CON 1993, p339, May 1993.
Sharp, B.H., Gurovich, Y.A., Fazeli, F.K., and Miller, E. (2013). Assessment of Sound Insulation Treatments, ACRP Report 02-31, Transportation Research Board of the National Academies, September 2013.
SHSC (2004). Analysis of Building Condition Audits and a Comparison of Ontario Non-Profit Portfolio with the Local Housing Portfolio. Social Housing Services Corporation (SHSC), Canada, 2004.
Stiffler (1986). Logan International Airport sound insulation program, J. Acoust. Soc. Am. Volume 80, Issue S1, pp. S68-S68 (1986).
Stusnick, E. et al. (1988). Pilot Sound Insulation Program at Baltimore/Washington International Airport, Wyle Research Report WR 88-16, July 1988.
Vigener (2010). Vigener, N. and Brown, M.A., Building Envelope Design Guide – Windows. In 'Whole Building Design Guide (WBDG)', National Institute of Building Sciences, http://www.wbdg.org/design/env_ fenestration_win.php, December 2010.
Wyle (1970). Final Report on the Home Soundproofing Pilot Project, Wyle Consulting Report WCR 70-1, prepared for the Los Angeles Department of Airports, March 1970.
Wyle (1987). Port of Seattle Phase 1 Sound Insulation Project on 21 Dwellings, Wyle Research Report WR 87-6, September 1987.
Wyle (1988b). City of San Bruno Aircraft Noise Insulation Project on Privately-Owned Dwellings – Phase 1 Final Report, Wyle Research Report WR 88-22, December 1988.

AIRPORT NAMES/LOCATION IDENTIFIERS

Lehigh Valley International Airport	ABE
Ted Stevens Anchorage International Airport	ANC
Hartsfield-Jackson Atlanta International Airport	ATL
Westfield-Barnes Regional Airport	BAF
Boca Raton Airport	BCT
Bradley International Airport	BDL
Boeing Field/King County International Airport	BFI
Nashville International Airport	BNA
General Edward Lawrence Logan International Airport	BOS
Buffalo Niagara International Airport	BUF
Bob Hope Airport	BUR
Baltimore/Washington International Thurgood Marshall Airport	BWI
Cleveland-Hopkins International Airport	CLE
Charlotte/Douglas International Airport	CLT
John Glenn Columbus International Airport	CMH
Cincinnati/Northern Kentucky International Airport	CVG
Dallas-Fort Worth International Airport	DFW
Detroit Metropolitan Wayne County Airport	DTW
Key West International Airport	EYW
Fresno Yosemite International Airport	FAT
Fort Lauderdale/Hollywood International Airport	FLL
Gerald R. Ford International Airport	GRR
Great Falls International Airport	GTF
George Bush Intercontinental/Houston Airport	IAH
Indianapolis International Airport	IND
Los Angeles International Airport	LAX
Orlando International Airport	MCO
Chicago Midway International Airport	MDW
Manchester Airport	MHT
General Mitchell International Airport	MKE
Minneapolis-St Paul International/Wold-Chamberlain Airport	MSP
Louis Armstrong New Orleans International Airport	MSY
Metropolitan Oakland International Airport	OAK
Ontario International Airport	ONT
Chicago O'Hare International Airport	ORD
Palm Beach International Airport	PBI
Portland International Airport	PDX
Phoenix Sky Harbor International Airport	PHX
Philadelphia International Airport	PHL
Pittsburgh International Airport	PIT
Theodore Francis Green State Airport	PVD
Reno/Tahoe International Airport	RNO
San Diego International Airport	SAN
San Antonio International Airport	SAT

Louisville International Airport-Standiford Field	SDF
Seattle-Tacoma International Airport	SEA
San Francisco International Airport	SFO
Norman Y. Mineta San Jose International Airport	SJC
John Wayne-Orange County Airport	SNA
St. Louis Lambert International Airport	STL
Syracuse Hancock International Airport	SYR
Toledo Express Airport	TOL
Tulsa International Airport	TUL
Tucson International Airport	TUS