



The following includes information to the support Noise Mitigation Program Assistance for Phase III of the Fort Lauderdale-Hollywood International Airport (FLL) Voluntary Residential Sound Insulation Program (RSIP). This information revises the plan undertaken for Phase IIA “Task C.1 – Update the Acoustical Testing Plan” in February 2012. The revisions to the Acoustical Testing Plan (ATP) follow guidance from the FAA’s Airport Improvement Program Handbook, the Interlocal Agreement (ILA) between Broward County and the City of Dania Beach and the recent release of the Federal Aviation Administration’s (FAA) Program Guidance Letter (PGL) 12-09, “Eligibility and Justification Requirements for Noise Insulation Projects”.

## **ACOUSTICAL TESTING PLAN**

The ATP that follows is recommended to be used for all phases of the FLL RSIP beginning June 1, 2014. The ATP describes the following:

- Housing Types and Locations;
- Number of Units to Test;
- Acoustical Issues;
- Acoustical Criteria;
- Acoustical Testing Methodology; and
- Compatibility Determination.

### **Housing Types and Locations**

In December 2008, the FAA issued its Record of Decision (ROD) concerning the Final Environmental Impact Statement (FEIS) for the development and expansion of Runway 09R/27L at FLL. The FAA’s ROD recommended sound insulation for residences that are located in the approved and eligible areas around FLL. As a result of the FEIS, the ROD established a program boundary that included all residential units that are within the 65 dB DNL contour, but also included units within a buffer area in order to humanize the contour to fit the local neighborhoods.

Phase III of the RSIP will include a mix of dwellings including single-family homes and multi-family structures. The units are located in three distinct neighborhoods located to the south and west of the airport.

## Number of Units to Test

The number of units requiring acoustical testing changed with the execution of the ILA. Per the ILA, residential units with an existing interior noise level less than 45 dB are considered compatible by the FAA and consequently will not receive acoustical treatments.

To be able to determine the existing interior noise level, acoustical testing will be required at most residential units. As a result of the ILA, all units included in Bid Groups 3800I and 3800J will be required to be acoustically tested to determine compatibility and provide statistical data for use setting inclusionary or exclusionary compatibility criteria. An analysis of all previous acoustical test data determined certain housing conditions may allow definitive compatibility decisions to be made without acoustical testing, effectively reducing the total number of units that need to be tested. As a result, compatibility decisions for Bid Groups 3800K and all future units moving forward will be determined both by acoustical testing and the application of the inclusionary or exclusionary housing criteria. This combined analysis will be conducted until a sufficient number of residential units have been determined to be eligible for acoustical treatment and placed into a bid group.

## Acoustical Issues

The typical treatment options for this project include:

- Acoustical windows;
- Acoustical doors;
- Central air conditioning;
- Attic insulation; and
- Ceiling/wall modifications.

A certain number of issues may need further evaluation on a case-by-case basis so effective acoustical treatments can be developed. These include the following:

- Flat or Low-Pitched Roofs;
- Vaulted or Cathedral Ceilings; and
- Exterior-Mounted Package Condenser Units.

## Acoustical Criteria

The FAA guidelines for examining building noise reduction are identified in the FAA's *Airport Improvement Program Handbook*, Order 5100.38C, Chapter 8, Section 2 – Noise Compatibility Projects, paragraph 812. The FAA approves assistance to airports in funding of sound insulation programs when a structure (which includes residences, schools and places of worship) are within the 65 dB DNL contour of the approved program.

Beginning in August 2012, the FAA guidelines in the AIP Handbook were replaced entirely by "Program Guidance Letter (PGL) 12-09. However, the compatibility criteria and design criteria expressed in the guidance will be applied to this program.

Based on FAA design criteria in the *Airport Improvement Program Handbook* and *PGL 12-09*, there are two ultimate goals of a sound insulation program. The FAA AIP Handbook guidelines state that:

- (1) *“The design objective in a residential noise insulation project generally should be to achieve the requisite NLR when the project is completed. (This is mathematically equivalent to achieving a DNL of 45 dB in all habitable rooms.)”*
- (2) *“Since it takes an improvement of at least 5 dB in NLR to be perceptible to the average person, any residential noise insulation project should be designed to provide at least that increase in NLR as a marginal minimum.”*

The FAA and ILA acoustical criteria are summarized in the following table.

**Summary of Acoustical Criteria  
Fort Lauderdale-Hollywood International Airport  
Voluntary Residential Sound Insulation Program**

<b>Compatibility Criteria</b>
Interior DNL levels of 45 dB or greater
<b>Design Criteria</b>
Minimum NLR increase of 5 dB
Maximum interior DNL of 45 dB

### *Acoustical Testing Methodology*

*Measurement Methodology* - Sound insulation measurements are typically based on using either an artificial noise source or using actual aircraft noise events. For the FLL RSIP, the acoustical consultant will use a sound insulation measurement technique based on the use of an artificial noise source. An artificial noise source allows measurements to be made at all of the structures during a brief measurement period, independent from aircraft over flights. The artificial noise source for the FLL program will be based on an average noise source spectrum as explained in the following paragraph.

*Noise Source Spectrum* – The noise source spectrum to be used as the exterior noise source for the FLL RSIP program will be based on measured aircraft noise levels. The acoustical consultant collected spectral data on a representative sample of aircraft that operate at FLL. This measured data includes a wide variety of aircraft under arrival and departure flows. The spectral data from the measured aircraft will be used to develop an average A-weighted noise spectrum of the typical fleet mix operating at FLL and will be used for determining the NLR of the various rooms measured for this study. The average exterior noise source spectrum will then be normalized to the DNL level for the study area.

The measurement procedure described herein has been developed to accurately measure outdoor-to-indoor noise level reduction (NLR) of rooms. The procedures generally follow those outlined in the American Society for Testing and Materials (ASTM) Standard E966- “Field

Measurement of Airborne Sound Insulation of Building Facades and Facade Elements”. The procedures conform to good practice in sound insulation programs. The efficiency and flexibility of the testing procedures are enhanced using methods and theories from other sources such as Leo Beranek’s “Noise and Vibration Control”. These are applied in addition to the ASTM standard to achieve the same level of accuracy.

The acoustical consultant will use a specialized field monitoring kit that includes a signal generator, amplifier, and an equalizer to produce a noise source of equal energy in each octave band (known in the acoustics field as “pink noise”). The noise source is relayed to a loudspeaker and the amplified pink noise is directed at the room or element of interest. The loudspeaker is placed on a tripod for measurements exposing the wall facades only.

The sound field produced by the loudspeaker will be directed at the room to be measured. The goal is to have a uniform sound field exposed to all of the surfaces of interest. With the loudspeaker pointed at the room, measurements are made both on the exterior and in the interior of the structure. Exterior octave band sound levels are measured and recorded with the loudspeaker in operation. Interior octave band sound levels are measured and recorded in each room with the loudspeaker in operation. Interior octave band sound levels are also measured and recorded without the loudspeaker to provide background or ambient sound levels.

Sound levels using the artificial noise source are used to determine the Outdoor/Indoor Level Reduction (OILR) in accordance with ASTM E966. With the loudspeaker pointed at the room, measurements are made both on the exterior and in the interior of the room. The exterior “near façade” measurements are reduced by three dB in each octave band. In some cases “near façade” measurements are not practical. In these cases, the acoustical consultant undertakes “free-field” exterior measurements of the noise source. These measurements are undertaken at a distance from the loudspeaker equal to the distance from the loudspeaker to the façade being tested during the period of the interior sound level measurements. Per ASTM E966 the “free-field” measurements require no adjustments to the sound levels. Interior element measurements are adjusted per ASTM E966 based on the angle of incidence of the noise source. A discussion regarding NLR is further described in the following paragraphs.

*Extent of Testing* - Per the ILA, residential units with interior noise levels that are less than 45 dB are considered to be compatible and not eligible for sound insulation treatments. Therefore, acoustical testing will be required at most residential units with certain exceptions for various housing conditions that are further explained in the following sections. Testing will be conducted on individual units until a sufficient number have been determined to be eligible for acoustical treatment and form a bid group. The acoustical consultant will conduct pre-construction acoustical testing for all habitable rooms within a residence to determine if the measured existing interior noise level is below 45 dB. Habitable rooms are by definition considered to be living rooms, dining rooms, family rooms, bedrooms, offices, kitchens, dens and enclosed sunrooms/porches if they comply with habitability criteria per the Florida Building Code. All noise measurements will be conducted in accordance with the procedures set forth by ASTM E966 - “Standard Guide for Field Measurements of Airborne Sound Insulation of Building Facades and Building Elements”. Measurements will be taken using an artificial noise source to determine the NLR in decibels (dB) to determine the types of acoustical treatments

necessary to meet the program and FAA goals. All measurements will be conducted with the loudspeaker mounted on a tripod.

*Noise Calculations* - Once the measurements have been completed the OILR of rooms are calculated from the measured exterior and interior sound levels in each octave band, as outlined in ASTM E966. The OILR values are then used to compute the NLR of aircraft noise as measured in A-weighted decibels (dBA).

*Noise Level Reduction (NLR) For Rooms* - NLR is a single number rating used for the comparison of the difference in the outdoor-to-indoor noise levels. This number is typically used to judge the overall effectiveness of sound insulation programs. The NLR of a room is dependent on the exterior noise source spectrum. In aviation sound insulation programs, the NLR is obviously based on aircraft as the noise source. For FLL, the acoustical consultant will use a FLL-specific composite noise spectrum for the exterior noise source. The noise source spectrum of the aircraft is A-weighted to resemble human perception and to be consistent with the FAA guidelines for assessing aircraft noise in communities. The indoor A-weighted noise source spectrum for each room tested in the program is obtained by subtracting the measured OILR from each octave band of the exterior A-weighted noise source spectrum. The A-weighted noise level is obtained by summing the energies in each octave band. The A-weighted NLR, based on a typical aircraft noise spectrum, is the difference between the outdoor and indoor A-weighted noise levels.

### Compatibility Determination

For each property requiring testing, the measured noise level reduction (NLR) of each room will be subtracted from the exterior DNL noise contour level to arrive at an interior DNL level. The interior DNL noise levels for each habitable room will be energy-averaged to arrive at an average interior DNL level for the whole residential unit. Interior DNL noise levels at 44.5 DNL or greater will be determined to be incompatible and eligible for participation in the RSIP.

An analysis of the 218 units have been previously acoustically tested has determined that certain housing criteria would result in data that can determine whether a dwelling will be definitively categorized as compatible or incompatible.

Units with the following acoustically significant material will be considered compatible per the guidelines and will not undergo acoustical testing nor receive acoustical treatments:

1. Hurricane Impact Windows - These windows are also commonly referred to as “impact resistant windows” or “hurricane windows”. The windows provided by the RSIP will be residential-type replacement windows consisting of two slabs of glass with a layer of polyvinyl butaryl (PVB) or lamination between the sashes. Though the glass may shatter on impact with flying debris, the inner membrane stays intact along with the sturdy frame around it. The windows are built to meet the high velocity hurricane zone (Zone 5) requirements for south Florida. Units with hurricane-impact windows already installed in a majority of the windows are likely to have interior DNL noise levels that are less than DNL 45 dB.

Of the 218 acoustically tested units, 16 units have hurricane impact windows in the majority of the windows. Of those 16 units, 13 units (81%) have interior noise levels less than 45 DNL. These units are considered compatible and are not eligible for the acoustical treatment package. The remaining three units were borderline in meeting the 45 DNL interior criteria. Generally, homeowners with hurricane-impact windows already installed are less receptive to replacing their windows.

Therefore, it is recommended that units with hurricane-impact windows installed in 50% or greater of the habitable rooms will be considered compatible and will not receive the acoustical treatment package. However, if an owner requests verification of the existing interior noise level, acoustical testing may be undertaken to determine whether the unit is compatible.

Units with the following acoustically significant material and or construction will be considered incompatible and will not be required to undergo acoustical testing. These units will be eligible to receive acoustical treatment:

1. Jalousie Windows – A jalousie window is a window which consists generally of parallel glass louvers set in a frame. The louvers fit together onto a track that can be tilted open and shut by a crank to control airflow through the window. While jalousie windows allow ventilation through the entire window area and are generally used to maximize cooling, they do not achieve a good seal between panes so they offer minimal insulation against noise. Units with jalousie windows in the majority of the rooms are likely to have existing interior DNL noise levels that are greater than DNL 45 dB.

Of the 218 units tested, four units had jalousie windows installed in the majority of the windows. All four units are with existing interior noise levels greater than 45 DNL and are determined to be incompatible and eligible to receive the acoustical treatment package.

Therefore, it is recommended that units with jalousie windows installed in 50% or greater of the habitable rooms be eligible for the acoustical treatment package. There is no need to conduct acoustical testing on these types of units.

2. Flat, Vaulted or Cathedral Ceilings – Units with ceilings that are flat, vaulted or cathedral style do not have the deep air space that is normally afforded by a traditional roof with attic space that is present above these ceilings. As a result they offer less insulation against noise due to the lack of air space and less mass in the roof/ceiling structure. Units that have flat or vaulted ceilings in the majority of habitable rooms are likely to have existing interior DNL noise levels that are greater than DNL 45 dB.

Of the 218 units tested, 28 units had flat, vaulted or cathedral ceilings in the majority of the rooms. A total of 27 units (96%) are determined to be incompatible and eligible for treatment with interior noise levels greater than 45 DNL.

It is recommended that homes where more than 50% of ceiling area in habitable rooms is vaulted, covered by flat roofs, or have cathedral ceilings be considered eligible for treatment. There is no need to conduct acoustical testing on these types of units.

3. Thru-Wall or Window AC Units – Units that have thru-wall or window air conditioning (AC) units traditionally offer less noise insulation. Thru-wall AC units typically fit through a sleeve in the wall which is not well sealed. Window units require part of the window to remain open with a simple piece of material closing up the remainder of the space. This is also typically a very poor insulating seal. In addition, the AC unit itself is not a good insulator against noise. As a result, units that have thru-wall or window AC units in the majority of the habitable rooms are likely to have interior DNL noise levels that are greater than DNL 45 dB.

Of the 218 units tested, 23 units had window or thru-wall AC units in all, or the majority of, the rooms. All 23 units are determined to be incompatible and eligible for treatment with interior noise levels greater than 45 DNL.

Therefore, it is recommended that units with window or thru-wall AC units installed in 50% or greater of the habitable rooms be considered eligible for the acoustic treatment package. There is no need to conduct acoustical testing on these types of units.

Based on the acoustical testing of the 218 units and an analysis of housing criteria, it is determined for approximately 33% of the units, a compatibility determination can be made without conducting acoustical testing. This is broken down as follows:

**Summary of Compatibility Determination  
Fort Lauderdale-Hollywood International Airport  
Voluntary Residential Sound Insulation Program**

Housing Element	Feature	No./% Units Based on Higher Exterior DNL <sup>(1)</sup>	Compatible (C)/ Incompatible (I)	Acoustical Testing Required (Y/N)
Ceiling	Flat, Vaulted, or Cathedral	28/13%	I	N
Window	Jalousie	4/2%	I	N
AC Unit	Window or Thru-Wall	23/11%	I	N
Window	Hurricane-Impact	16/7%	C <sup>(2)</sup>	N
All Others	---	147/67%	<sup>(3)</sup>	Y
Total		218/100%	---	---

- Notes: (1) Based on acoustical testing of 218 units thru Bid Group 38001.  
(2) Units with hurricane-impact windows are not normally eligible for treatment although a homeowner may request testing to verify existing interior noise levels.  
(3) Eligibility based solely on acoustical testing.

Therefore, for the estimated remaining 67% of the units located within the program boundaries, we will be unable to determine the existing interior noise level based on the above identified acoustically significant materials and construction and acoustical testing will be required. Although slight variations are expected, one would assume the percentages for units which can be determined to be compatible, incompatible or those that require acoustic testing will remain somewhat consistent through the remainder of the project.

Additional future acoustical testing may reveal acoustically significant housing conditions that could lead to additional determinations of program compatibility without further acoustical testing.