inter·noise 2021
1–5 August | Washington, DC

Proacústica Handbook: Noise and Vibration Control in Building Installations

José Augusto Nepomuceno[1]
Acústica & Sônica
Rua Girassol, 139 cj 12
05433-000 São Paulo – SP
Brazil

Priscila Wunderlich[2]
Former Manager of Technical Activities of Proacústica

ABSTRACT

Proacústica is a nonprofit entity created in 2010 to congregate companies and professionals willing to leverage the development of acoustics in Brazil. Three technical committees (TCs): Environmental Acoustics, Building Acoustics, and Room Acoustics, contribute to the drafting of laws, standards, production of technical content, and integration between different players of the market.
By 2021, the Room Acoustics TC incorporated three Working Groups: Special Rooms, Schools and Noise Control and Vibration Control – the last one dedicated to the Proacustica Handbook: Noise and Vibration Control In Building Installations. The purpose of this publication is to describe the step-by-step measures to implement noise and vibration control strategies in buildings.
These strategies are aimed at the particularities of the Brazilian market at the moment and also a way to improve how M/E/P equipment manufacturers, installers, designers, and acoustic consultants approach the subject from the design to the construction,
Important technical discussions among participants included: the use of sound pressure versus sound power data for equipment; the sound rating for diffusers, VAVs, and other ductwork devices; vibration isolation guidelines, among other topics.
This paper presents the Handbook structure, relevant discussions, and recommendations to be published as a final document by the end of 2021.
.

1. INTRODUCTION

The idea of preparing this Handbook arose from the lack of standardized specifications or best practices for noise and vibration control in building installations in Brazil. This publication addresses M/E/P engineers, contractors, manufacturers, building designers, and acoustical consultants.

[1] jan@acusticaesonica.com.br

[2] mail2@example.com

Most of the recommendations and analysis are based on the experience of each professional creating a large variation on how working scope is proposed. For the point of view of the clients it is unclear the role of acoustician in the M/E/P design.

The absence of a best practice description creates difficulties in the most diverse interfaces of the professional activity. Some designers specify sound limits to be fulfilled by the equipment vendors; other designers don't go into this subject, for example. This issue extends to virtually all building installation systems as well as noise and vibration control devices such as noise attenuators, vibration isolation mounts, inertia bases, or duct lining.

Specifying criteria according to international standards protect the design quality. However, can face obstacles because not all local manufacturers have their products tested, even because there is no aeroacoustics laboratory in Brazil to perform such tests. One of Handbook's objectives is to encourage local manufacturers to test their products abroad while local laboratories are unavailable.

The Noise and Vibration Working Group brought promoted technical meetings gathering members and non-members companies to organize workshops as a collaboration to the *Proacústica Handbook: Noise and Vibration Control in Building Installations.* The publication should gather the information covering subjects most frequent in the design and construction. The designers and contractors will find recommendations in the Handbook helping to improve acoustical quality of the local constructions.

It is not the purpose nor the intention of the WG to present new or unpublished information. Contrary, much of the data is described in the technical literature, but it is often scattered or complex to the non-specialized reader. The section related to commissioning and post-installation will bring information that is sparse in the technical literature.

The publication is work-in-progress, and this paper presents the status now.

2. HANDBOOK STRUCTURE

The structure of the Handbook covers the main interests of Proacústica associates and the WGs perception of the needs of the Brazilian market. The structured sections are:

- Acoustics – concept.
- General guidance for noise and vibration control.
- Equipment sound data.
- Attenuation and sound generation in the ductwork.
- Sound propagation to outdoors.
- Vibration isolators specifications and selection guidelines.
- Commissioning.

Depending on the progress of the publication the WG can add specific sections. It is important to emphasize that Proacústica has published manuals covering different subjects that can be consulted with this Handbook.

3. ACOUSTICS - CONCEPTS

This section describes the main concepts of acoustics applied to noise and vibration control in building installations as:

- Sound pressure, sound power, and sound intensity.

- dB, dB(A), and acoustic metrics.
- Characteristics of sound emitted by machines as a function of time and frequency.
- Sound generation characteristics in air duct and pipe network.

4. GUIDANCE FOR NOISE AND VIBRATION CONTROL

This section presents the steps for noise and vibration control analysis. Besides the simple specification of acoustical devices as sound attenuators or vibration mounts, there are essential aspects of design such as:

- Role and collaboration of the acoustician in the M/E/P design.
- Location of noisy equipment in relation to acoustically protected areas to the inside and outside of the building.
- Air or water flow velocity limits in ductwork and piping.
- Positioning of noise attenuators.
- Machine room dimensions.

Commonly, for typical corporate towers or similar projects, the acoustic consultants start too late in the design process to relocate M/E/P room location, for example. Exceptions are those high-profile projects for performing arts centers or other critical listening spaces.

Proacústica encourages having acoustic consultants collaborating with the design team in the early phases of any construction: corporate towers, airports, hospitals, theaters, and so on.

5. PRESENTATION OF ACOUSTIC DATA

5.1 Equipment

There is misinformation on the sound data submission from equipment in Brazil and abroad. Except for equipment suppliers engaged in the quality assurance of their products, we found information problems such as:

- Unclear metrics, whether pressure or sound power.
- Using A-weighted data presented as octave bands without proper identification. A risk when developing sound attenuation calculations for ductwork, for example.
- Data presented only in terms of NC or dB (A) for equipment.
- Data of the ventilator presented as the AHU.
- Omitted information.
- Data estimated through calculation and presented as measured.

Many types of equipment sold in the Brazilian market are assembled abroad, and in this case, the manufacturers submit their standard data, including cooling towers, fans, AHU, chiller. The WG intends to improve the methods of how manufacturers submit the sound data of their products.

5.2 Pressure or sound power?

One of the discussions in the WG workshops was about using sound pressure or sound power to describe equipment sound radiation.

The typical recommendation for using sound power level rather than pressure level in quantifying equipment noise is that the power radiated doesn't depend on the acoustical properties of the surroundings. In contrast, the pressure depends on distance, room absorption, or the geometry of the installation.

In the classical relationship, the sound pressure level is assumed to drop off at the rate of 6 dB per doubling of distance, initially, until the reflected energy begins to dominate; at some point, the level becomes constant and independent of greater distances.

For larger sources installed outdoors or for a distribution of several sources over an extended surface, the sound pressure in the vicinity of the source is not related to the radiated power by the simple inverse-square distance relation. For the indoor installations, there is growing evidence that the relationship between the sound power and the resulting sound pressure at a point in the room does not follow the direct/ reverberant field relationship generally assumed in current practice. For the actual situation, in typical mechanical rooms, the "constant" reverberant field level cannot be found.

For situations where the absorptive treatment is concentrated on a single surface it is recommended to estimate the sound pressure level at specific distance, based on the sound level measured close to the equipment, rather than to calculate it using the sound power level and the classical reverberant room equation.

In the case of outdoor equipment, the use of sound power level for source characterization is recommended. If the sound pressure level is used, then the reference distance should be large with respect to the source dimensions, preferably three times the major unit dimension.

Sound power level is recommended for all air moving equipment and for certain refrigeration items.

The use of sound pressure level at a distance such 1 m from items such as pumps, centrifugal chillers, transformer, among other equipment could be accepted.

For air diffusers, following the industry trend, the recommendation is to accept the use of sound pressure levels rated as NC single number.

5.3 Flow Devices

One local supplier[3] of devices for diffusion and control of airflow, such as diffusers or VAVs has acoustic data tested in the laboratory with standardized procedures. The products are produced locally under license from the central headquarters where they were tested.

When the technical specification states that the systems shall be acoustically tested and certified, it addresses or suggests a single brand or proposes the importation of a product. This is a recurrent conflict, mostly in public contracts.

WG encourages national manufacturers to test their products in international laboratories until a laboratory is built in Brazil for such tests.

The WG encourages that specification requests tested data observing industry standards for:

- VAV: sound power level for flow discharge and casing radiation.

[3] In our best information at the moment of reviewing this paper.

- Diffusers and grilles: NC data.

5.4 Sound Attenuators

The situation of sound attenuators is like airflow equipment. Local manufacturers submit tested data for pressure drop, dynamic sound attenuation, and regenerated noise. As in the airflow devices, the attenuators are produced locally under license from the central headquarters or by local fabrication license. Unfortunately, some of the reported data is based on old and obsolete tests and should be updated.

The WG encourages the manufacturers to update the performance data as necessary in international laboratories until a unit is built in Brazil to test such devices.
The typical specification of sound attenuators shall request the following data tested per ASTM or ISO standards:

- Dynamic insertion loss.
- Noise regenerated.
- Pressure loss.

6. SOUND ATTENUATION IN DUCTWORK

The technical literature describes methods for evaluating propagation, attenuation, and sound generation in the ductwork.

This section will cover the main mechanisms that designers should note, such as sound attenuation per duct characteristics, the placement of sound attenuators, risks of crosstalk, and break-in.

7. SOUND PROPAGATION OUTDOORS

The section will cover the main precautions regarding sound control for equipment or devices that may impact outdoors areas such as sidewalks, residential buildings, or even external building areas such as entrances or rooftops.

Typical items for environmental noise control are air chillers, cooling towers, power generators, louvers for air suction or discharge.

8. VIBRATION ISOLATORS

Qualified manufacturers of metallic or elastomeric vibration isolation mounts are available to the Brazilian market and producing locally. The range of products covers isolators to support mechanical machines, piping, transformers, floating slabs, among other items. The Authors are not aware of any vendor in Brazil for prefabricated isolator curbs.

Most M/E/P designers and acoustical consultants indicate vibration isolation systems for building installations. When analyzing several difference references, the Authors found a prevalence in a short specification line as "*the vibration isolators shall have 5 Hz of natural frequency*", for example. One of the objectives of this Handbook is to provide a baseline for a typical specification, including the following topics:

- The vibration isolation mounts selection concerning the structure, equipment characteristics, and location, for example, inside or outside, exposure to corrosive attack, etc.
- Typical details the contractor shall observe in the vibration mount installation.

- Avoid statements as "*x natural frequency or more*." Such specification format is not rare, and it is detrimental to the objectives of the vibration control task.

9. COMMISSIONING

A recurrent subject discussed in the WG workshops is the absence of procedure or checklist for accepting the installations. Sort of punch list ou compliance list. Some of the items to be developed in this section is:

- Vibration isolators installation with respect to the static deflection in different mounts in the same equipment; the horizontal unalignment tolerances.
- Sound measurements of machinery equipment installed in mechanical rooms and at the outdoors.
- Measurements of flow noise compared to the design criterion.

10. ACKNOWLEDGMENT

We gratefully acknowledge Proacústica board and members for the permanent support to the Room Acoustics Technical Committee