Community Noise Impact of Sewage Treatment Plants: Discussion About Acoustic Treatment of Pumping Rooms

Belderrain, Maria Luiza[1]
CLB Engenharia Consultiva
Rua Paracatu, 616 – Parque Imperial – São Paulo – SP, Brasil

Vaidotas, Rafael[2]
CLB Engenharia Consultiva
Rua Paracatu, 616 – Parque Imperial – São Paulo – SP, Brasil

Matsuoka, Daniel[3]
CLB Engenharia Consultiva
Rua Paracatu, 616 – Parque Imperial – São Paulo – SP, Brasil

Rosa, Laura[4]
CLB Engenharia Consultiva
Rua Paracatu, 616 – Parque Imperial – São Paulo – SP, Brasil

ABSTRACT

This paper presents technical considerations on acoustic and ventilation designs of air blowers used in most Sewage Treatment Plants. These equipment may cause annoyance to people living in the neighborhood of these plants. Acoustic treatment should take into account the heat emitted by these equipment. In order to achieve optimal system operation, maximum room temperature must be controlled; therefore, air intake and air discharge attenuators must be appropriately sized. To illustrate this subject, the acoustic design made for one specific Sewage Treatment Plant located in the state of São Paulo, Brazil, is shown.

Keywords: community noise; acoustic treatment; pumps; heat and ventilation.

I-INCE Classification of Subject Number: 52

[1] malu@clbengenharia.com
[2] rafael@clbengenharia.com
[3] contato@clbengenharia.com
[4] laura@clbengenharia.com

1. INTRODUCTION

Located at São Paulo's coast, a new sewage treatment station is being constructed near a residential area. Due to its proximity to the residential area, an acoustical project was needed to adjust the station operation to the federal and municipal environmental legislation. However, since pumps generate heat, forced ventilation will also have to be provided to the station, so that the equipment operates accordingly.

The station is composed of a pumping room with non-acoustical louvers positioned at the top of the room, water ducts coming in and out of the room at an axis height of 1.0 meter and diameter of 1.2 meters, with walls composed of masonry.

Sewage lifting stations consists of a set of hydraulic devices that transports the waste from lower areas to regions with higher elevation. In general, they are located far from inhabited areas, but this station is only 13.0 meters away from a residential building/receiver, which belongs to a Municipal zoning establishing criteria equivalent to 55/50 dBA at day/night periods.

Considering that each pump emits noise levels up to 89 dBA, the sound pressure level inside the room can easily achieve 91 dBA when considering the walls and the reflective settings of the room, corroborating to the increase of reverberation and subsequent increase of the noise levels.

This paper emphasizes the importance of a comprehensive analysis of the problem, which isn't limited to the acoustic attenuation of the mechanical source but also to the dissipation of the heat generated by the machine.

2. METHODOLOGY

The station operation involves a pumping room with dimensions of [20.5 x 11.3 x 7.90] [Length x Width x Height] meters, containing two pumps that works alternatively.

The major concern on evaluating the pumps operation is to conciliate the room noise attenuation with the necessary ventilation for their operation, as a function of the receiver's distance.

Depending on the case, natural ventilation is not enough to supply the necessary air exchange required from the pumps. Therefore, a study was carried out and a forced ventilation system was selected to guarantee the minimum necessary ventilation, while still attending to acoustic criteria. With a defined system, the acoustic treatment was designed to treat the noise from the pumping room and forced ventilation equipment, guaranteeing the overall attenuation result.

2.1 LEGAL AND REGULATORY FRAMEWORK

The sewage treatment station is inserted in Zone of Urban Expansion 4 – Z4 – according to the Municipal law. This zone is characterized by a strong predominance of residential uses. Law n°4023/2015 establishes the maximum permitted levels of noise for outdoor environments, relating them to the levels recommended by the Brazilian Standard NBR 10.151/2000: Noise Assessment in Inhabited Areas aiming at Community Comfort, presented in Table 1. Thus, considering that the zone is predominantly residential, the criteria for the day / night periods of 55 dBA / 50 dBA can be adopted.

Table 1: Maximum permitted noise levels for outdoor area.

Zoning	Day	Night
	LAeq, dB	
Residential	**55**	**50**
Commercial	70	50
Industrial	70	50

2.2 VENTILATION COMBINED WITH ACOUSTIC ATTENUATION

From the technical specifications of the pumps, such as flow, power, motor rotation, operating temperature and pressure, it was concluded that a forced ventilation system with axial exhausts would be the best option to guarantee the necessary air exchange for the pump operation.

From the characterization of the sound sources, through its operational parameters related to air flow, rotation, available static pressure etc., it was possible to estimate the sound power level of the pumps. From there, a project of acoustic treatment to the installation was established to meet the noise criteria.

2.3 Pump noise levels

According to the manufacturer's (KSB) catalog, for the model RDLO 700-980 A GC P F, the technical specifications are as shown at table 2:

Table 2: Technical specs for the KSB RDLO 700-980 pump.

Nominal flow rate	2	m^3/s
Fluid	Water	
Pump rotation	714	rpm
Power	1152	HP

Through the pump technical sheet, the reference sound pressure level LpA can be obtained for a distance of 1.0 meter, as seen at figure 1. The sound components per octave band were determined through the correction presented at table 3.

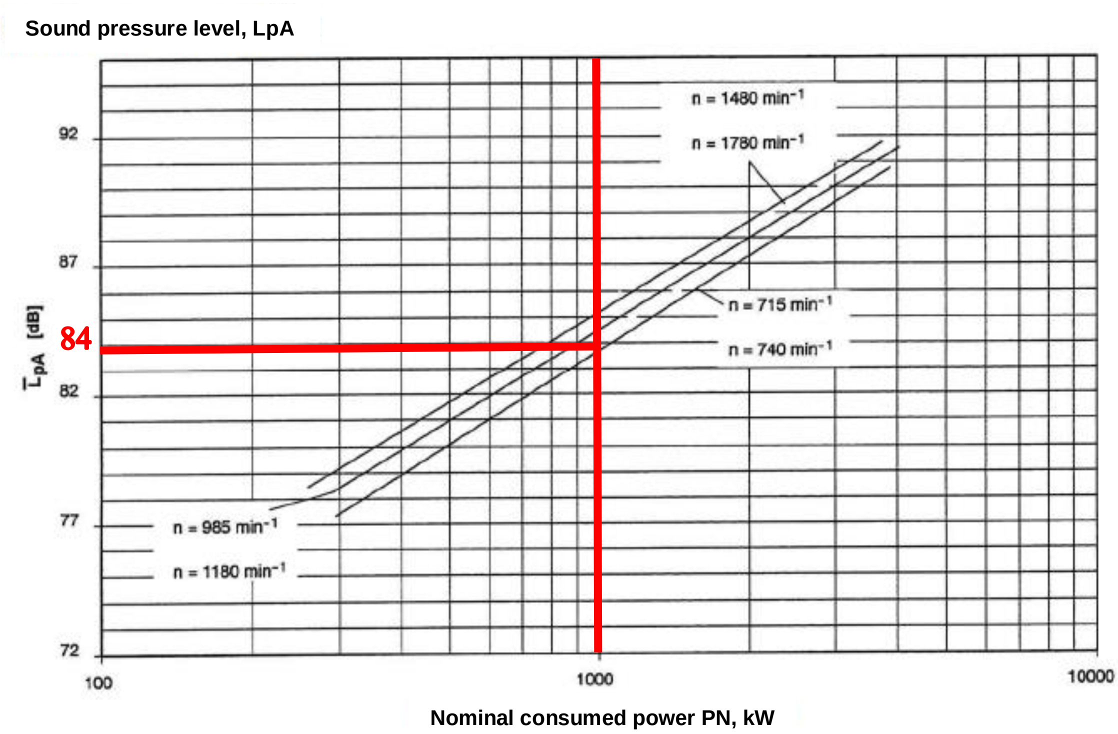

Figure 1: Relation between sound pressure levels and Power consumed.

Table 3: Correction on LpA per octave band frequency.

	Octave band frequency, Hz							
RPM	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
≤ 950	-6	-3	0	-2	-4	-8	-12	-16
Até 2.000	-4	-3	-2	-1	-4	-8	-12	-16

Table 4: Resulting sound pressure levels per pump at a distance of 1.0 meter.

Description	Power, kW / Rotation, rpm	63	125	250	500	1000	2000	4000	8000	A
KSB RDLO 700-980	875 / 790	56	76	74	85	80	77	74	68	87
Lp = 88.0 @1.0m		78	81	84	82	80	76	72	68	88

2.4 Adopted ventilating system and noise levels

The ventilation study for the pumping room analyzed the viability of adopting natural ventilation and whether system would be the best option: Natural ventilation x Forced ventilation. The obtained results were calculated considering the volume of the pumping room and data of heat emission to the environment, according to table 5.

Table 5: Required parameters for the ventilation of the Pumping room.

Power dissipated to the environment	57.6	kW
Flow rate	22190	m³/h
Temperature variation	10	°C
Pressure loss	9	mmca

In this case, the open area required for natural ventilation would be 24.0 m². In order to provide this amount of area, it would be necessary to adopt acoustical louvers, which has a 1/3 of its area permissive to air passing. Therefore, it would be required roughly 72.0 m² of louvers to cover this open area, whilst the Pumping room has 502.44 m² of walls. The average price of an acoustical louver, in Brazil, per m², is about USD 260, totaling an investment on acoustical louvers of roughly USD 18.720.

With the ventilation need being covered, the noise attenuation was calculated. Considering that the pumping room emits around 91.0 dBA through its openings, and that an acoustical louver mitigates up to 10 dBA, the expected noise level @1.0 meter of the louvers would be of 81.0 dBA. Considering the distance to the Receiver (13.0 meters), the noise decay would be of 65 dBA, 10 dBA and 15 dBA above the day and noise criteria.

Therefore, it is observed that the area of attenuation for natural ventilation is expensive due to the required open area and ineffective, not being able to attenuate the noise accordingly, making this proposal impracticable. Thus, the forced ventilation system was adopted.

2.4.1 FORCED EXHAUST VENTILATORS

In order to guarantee the necessary air exchanges for the operation of the pumps, a system with 4 axial exhausts, model MOTOVENT ATD-600 / 8-6 was established. Table 6 presents the technical specifications of the selected equipment:

Table 6: Ventilators technical specifications.

Flow rate	6.720	m^3/h
Pressure	9	mmca
Power	1	cv
Rotation	1.150	Rpm

According to its characteristics, the sound pressure level emitted by each exhaust fan is 80 dBA. In order to obtain the sound spectrum of the equipment, base values of the ASHRAE System volume were adopted, which provides studies with various models of fans. Table 7 presents the spectrum of an axial tube fan with a diameter of <1.0 m.

Table 7: Octave spectrum of the ventilator with diameter <1.0 meter.

	63	125	250	500	1k	2k	4k	A
Ventilator	45	56	69	74	75	75	69	80,2

3. CONCEPTUAL ACOUSTIC PROJECT

With the discretized and quantified sound sources, the impact of noise from the pump operation to the surrounding environment (neighboring residences) was calculated, exceeding the criterion established for the location in up to 22 dBA. Figure 2 shows the layout of the Pumping house without acoustic treatment.

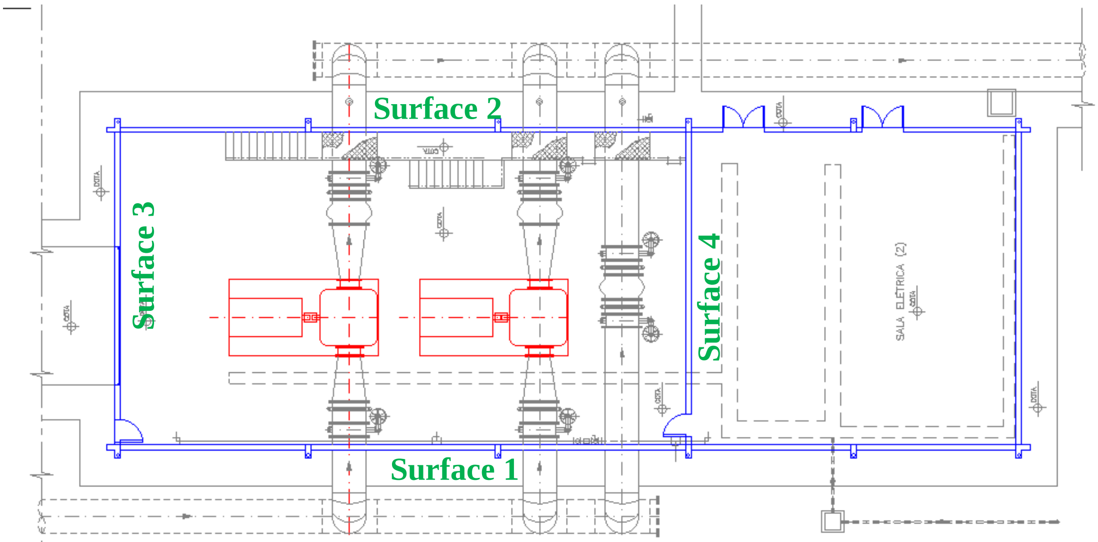

Figure 2: Pumping room w/o acoustical treatment.

From this value, a project of acoustic treatment of the Pumping room was developed to attenuate the noise coming from the pumps and respective air exhaust system.

3.1 ACTIONS REQUIRED

The acoustic Project covered the following actions, briefly described:

a) Application of absorbent coating based on non-combustible mineral fiber, 50 mm thick and sound absorption index of $\alpha \geq 0.8$. The coating area required for the desired absorption into the room corresponded to roughly 470 m², distributed on the 4 surfaces/walls and ceiling of the room. The sound reduction calculated for this treatment corresponded to 9.3 dBA;

b) Air intake noise attenuators: 2 attenuators were designed with dimensions of [2.20 x 1.10 x 1.70] [Width x Height x Length] meters, consisting of 100 mm thick slats and an open area of 50% or 1.21 m² each. It is recommended that such attenuators be positioned at low elevation for cold air intake.

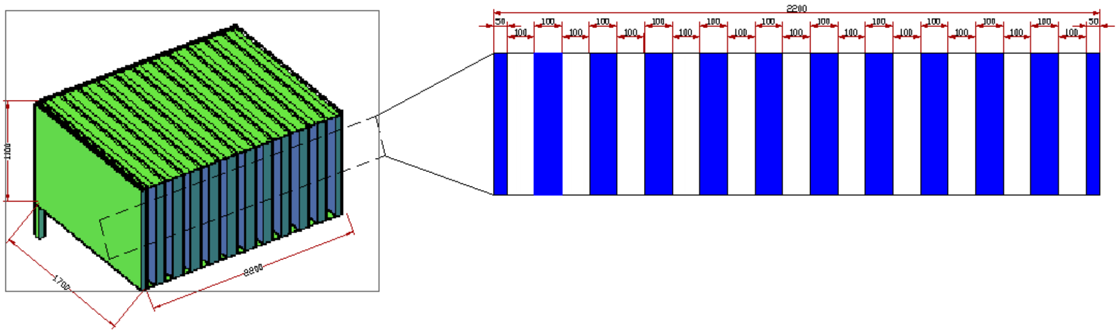

Figure 3: Pumping room air intake noise attenuator.

The facade intended for air intake with the dimensioned acoustic treatment will produce in the receiver environment a noise level LAeq = 47.5 dB lower than the acoustic criteria of 50 dBA for the night period;

c) Hot air discharge Attenuators: to promote the withdrawal of heat from the Pumping room, it is required the installment of 4 specially designed exhaust fans, with flow rate of 6.720 m³/h and static pressure of 9 mm per unit. The noise attenuators (each to its respective fan) coupled to each equipment must have the following dimensions: [1.20 x 0.60 x 1.50] [Width x Height x Length] meters, with 100 mm thick slats and 50% open area, which totals 1.44 m².

Exhaust fans and discharge air noise attenuators must be positioned at the opposite wall and at a higher quota than that of the air intake attenuators, to optimize the hot air removal. This facade, considering the dimensioned acoustic treatment, will provide at the receiver a noise level Laeq = 48.4 dB lower than the acoustic criteria of 50 dBA for the night period;

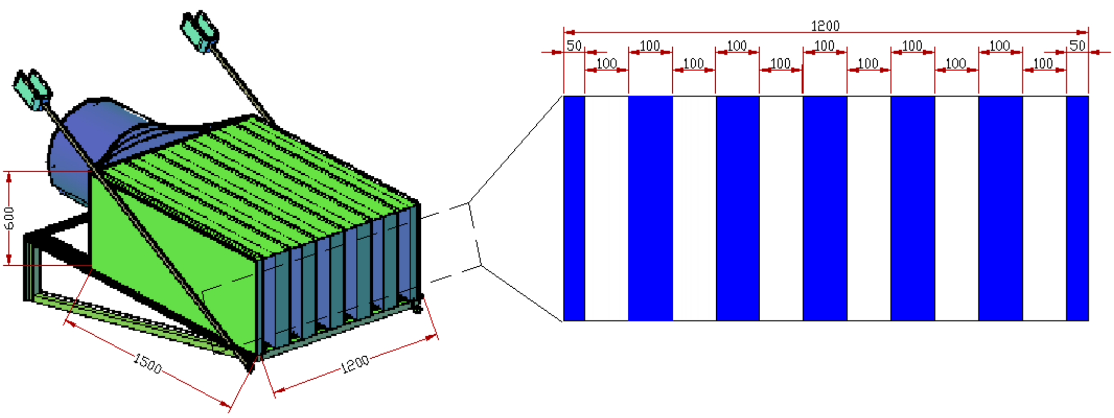

Figure 4: Pumping room air discharge attenuator.

d) Acoustic door: there will be 3 acoustic doors in total, 2 double-leaf and 1 single-leaf. The doors will consist of panels in smooth metal plate with mineral fiber core. Depending on the internal noise level in the room, the doors should have a sound insulation index Rw> 34 dB to meet the 50 dBA criteria in the receiver environment;

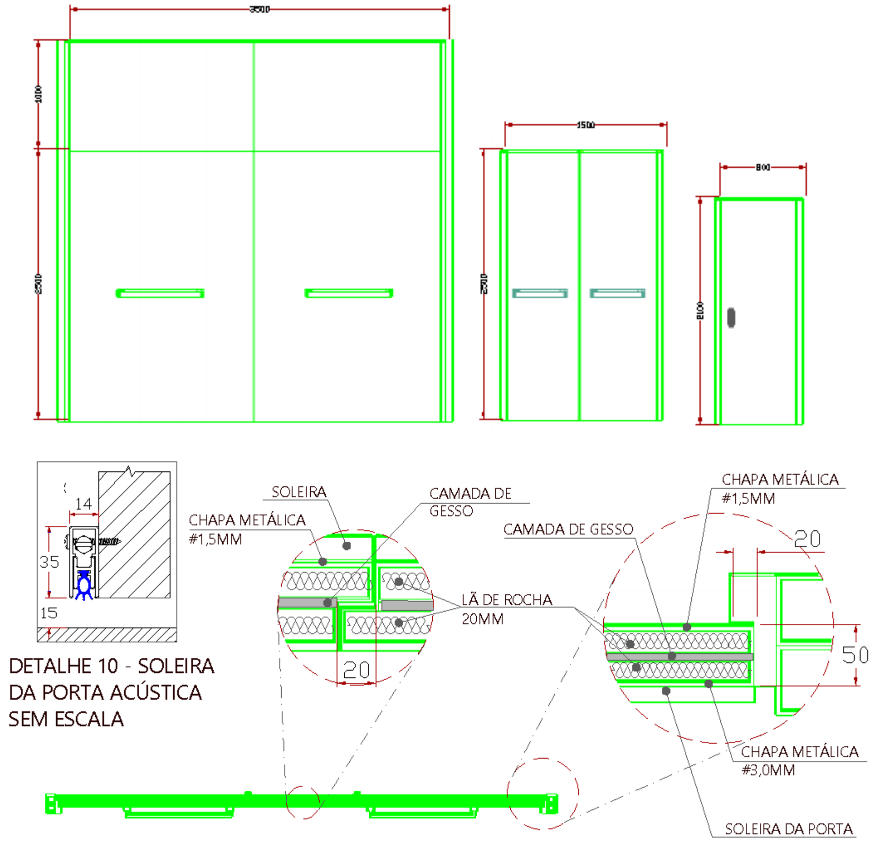

Figure 5: Acoustic doors details.

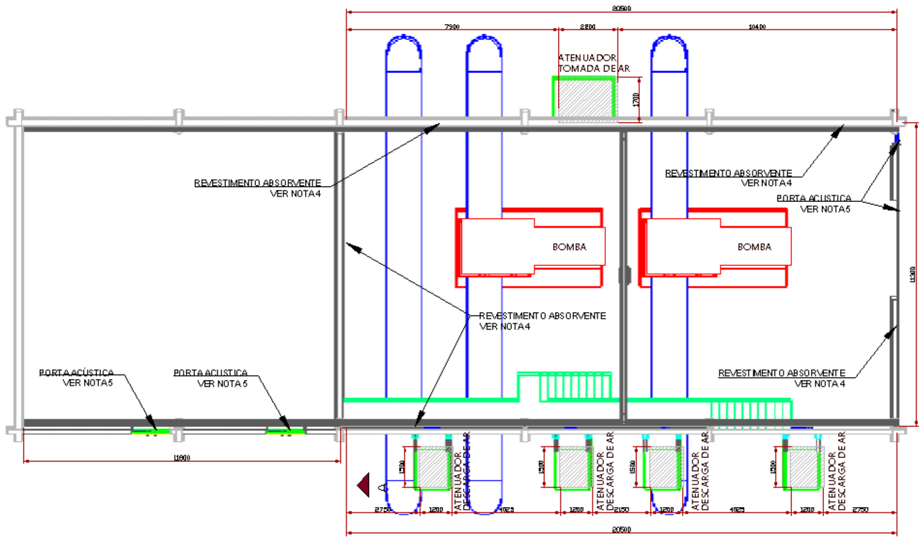

Figure 6: Pumping room with acoustic treatment.

4. CONCLUSIONS

Since the studied Pumping room is located near a residential area, it was verified the need to develop an acoustic treatment project in order to attend to the Municipal noise criteria at day and night periods.

Once the pump dissipates heat and its functioning depends on a determined temperature, it was verified the need to develop a study of the air exchange in order to provide a good functioning to the equipment. This requirement has lead to the dimensioning of air ventilation predicting the air intake and discharge needed for it.

This necessity shows that there is a direct correlation between acoustic analysis and ventilation requirements when dealing with Machine rooms, such as a Pumping house.

Therefore, the developed project includes the acoustic treatment both in the air intake and air discharge (including the 4 dimensioned exhausts/ventilators), absorbent coating inside the room and insertion of acoustic doors, resulting in the use of the materials listed in quantities at table 8.

Table 8: Materials quantified for the acoustical treatment.

ITEM	QUANT.	UN.
Exhaust Axial ATD 600/8-6	4	un.
Noise attenuator – air discharge: (1200x600x1500)mm	4	un.
Noise attenuator – air intake: (2200x1100x1700)mm	1	un.
Acoustic Panels (Surfaces/Walls). Model: 50mm	209,9	m²
Acoustic Panels (Ceiling). Model: 50mm	259,2	m²
Single-leaf Acoustic Door: (2100x800)mm - Model 34dB	1	un.
Double-leaf Acoustic Door: (3500x3500)mm - Model 34dB	1	un.
Double-leaf Acoustic Door: (2500x1500)mm - Model 34dB	1	un.

All the presented treatments, when implemented together, are enough to adjust the noise generated by the pumps at the residential neighborhood, attending to the criteria established for day and night periods, respectively, 55/50 dBA.

Thus, it is concluded that the treatments herein are adequate and sufficient for the acoustic achievement of the Sewage treatment station/Pumping room.

5. ACKNOWLEDGEMENTS

We would like to thank José Luiz Rocha Belderrain for his contribution to this paper.

6. REFERENCES

1. Leo L. Beranek and István L. Vér, *"Noise and Vibration Control Engineering – Principles and Applications"*, edited by Leo L. Beranek and István L. Vér, John Wiley & Sons, New York (2006)

2. NBR 10.151/2000. "*Avaliação de Ruído em Áreas Habitadas visando o Conforto da Comunidade*", publicação ABNT, 2000.

3. S. R. Bistafa. "*Acústica Aplicada ao Controle de Ruído*". Edgard Blücher, 2006.