EXPERIMENTAL INVESTIGATION FOR ULTRA FREEZERS NOISE REDUCTION

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Abstract

Reduction methods for ultra freezers noise emissions are here studied. The investigated freezer is the model “PLATINUM 750 V”, manufactured by Angelantoni Industrie S.p.a.. An intensity and a vibration measurements campaign has been led in order to individuate freezer noise characteristics. A sound pressure measurement campaign have been also carried out for low frequency noise components determination; a comparison has been made between power levels obtained by two measurement methods: intensity and pressure level measurements. Measurements results have shown that freezer fan and compressors are the main noise sources. Thus, some vibration and acoustic insulation solutions have been proposed and realized. Noise reduction solutions performances have been verified by a measurement campaign.

INTRODUCTION

Ultra freezers allow to preserve blood and plasma specimens at very low temperatures (about -80°C). They are usually characterized by high thermal insulation and safety conditions. Thus, this kind of freezers is largely spread for biomedical applications. Ultra freezers are often installed inside hospital laboratories. For these reason, noise emissions may cause annoyance to the researchers and to the hospital patients. Noise emissions reduction methods are here studied regarding a custom ultra freezer (model “PLATINUM 750 V”, realized by Angelantoni Industrie S.p.a., an Italian manufacturer). The research has been carried out within an agreement between the Perugia University Acoustic Laboratory and Angelantoni Industrie S.p.a. An intensity and vibration measurements campaign has been led in order to individuate freezer noise characteristics. A sound pressure measurement campaign have been carried out in order to individuate low frequency noise components; freezer noise power levels have been evaluated by integrating low frequency sound pressure measured levels with sound intensity measured levels. Measurements results have shown freezer fan and compressors are the main noise sources. Vibration and acoustic insulation solutions have been proposed and realized. An 11.5dB average vibration level reduction and a 4.5dBA sound power level reduction have been obtained by the proposed solutions.

THE INTENSITY MEASUREMENT CAMPAIGN

Platinum 750 V ultra freezer acoustic characteristics have been investigated. Platinum 750 V is constituted by an external inox steel coating which contains the internal inox steel freezer container. Freezer panels are thermally and acoustically insulated by polyurethane foaming and the installation of Vacuum Insulation Panels. Freezer cycle elements are placed on the freezer basement. An intensymetric measurement campaign has been carried in order to individuate Platinum 750 V noise power level. Measurements have been led in a hemianechoic room on 45 points, placed on a fictitious parallelepiped surface which surrounds the noise source (see Figure 1). Surface dimensions are x=2.1m, y=2.1m, z=2.52m. Measurement points number and positions have been chosen in according to ISO 9614-1/93 [1].

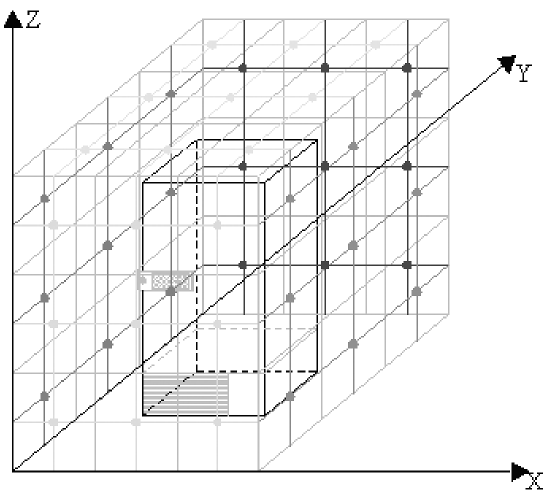

Figure 1: Intensity measurements surface

Measured noise power level is 73.3 dBlin and 68.9 dBA by intensity method. Power spectrum is reported in Figure 5. A 125 Hz main noise component has been individuated: this component is due to the fan which is placed in the freezer basement (see Figure 2). In fact, main noise component due to a fan noise source is [2]:

$$f_v = \frac{n \cdot rpm}{60} = \frac{5 \cdot 1500}{60} = 125 \text{ Hz} \quad (1)$$

where n is the number of fan blades (n=5) and rpm is the fan rounds per minutes (rpm=1500). Intensity noise map is shown in Figure 3. Highest intensity levels are localized at the lower measurement points because noise sources are placed in the freezer basement.

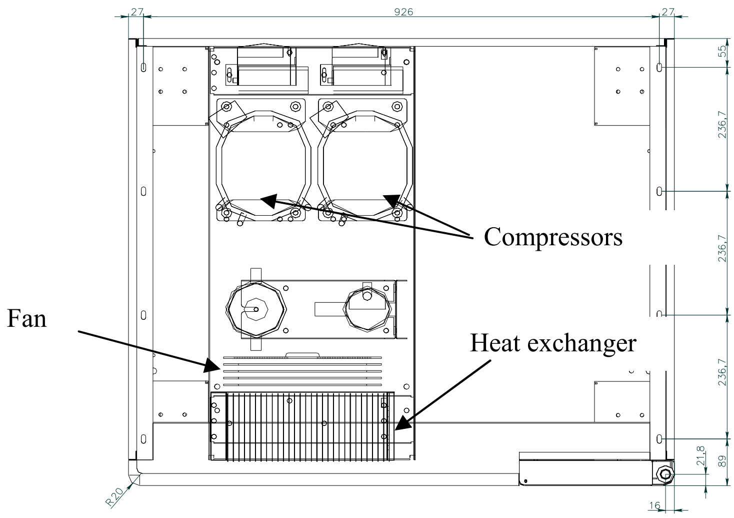

Figure 2: freezer basement scheme

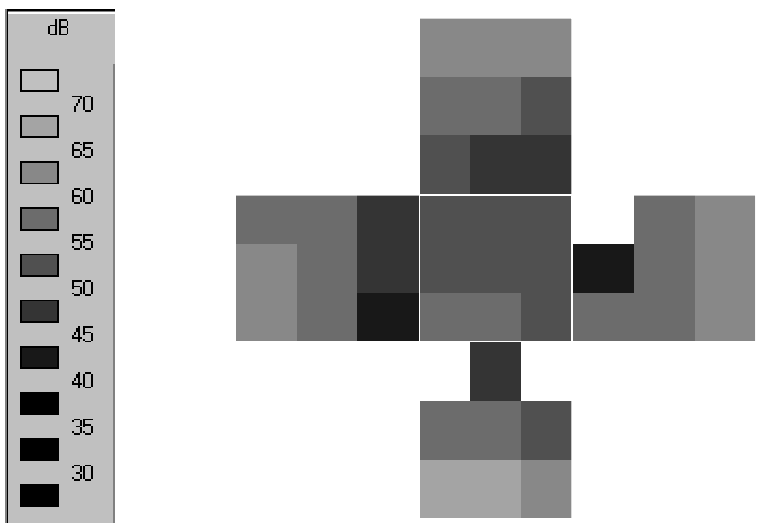

Figure 3: intensity level noise map

THE VIBRATION MEASUREMENT CAMPAIGN

A remarkable contribute to the global freezer noise is solid-borne noise. Thus, a vibration measurement campaign has been led in order to individuate possible correlations between acceleration level spectra and the previously measured power levels ones. Ten measurement points have been individuated (see Figure 4).

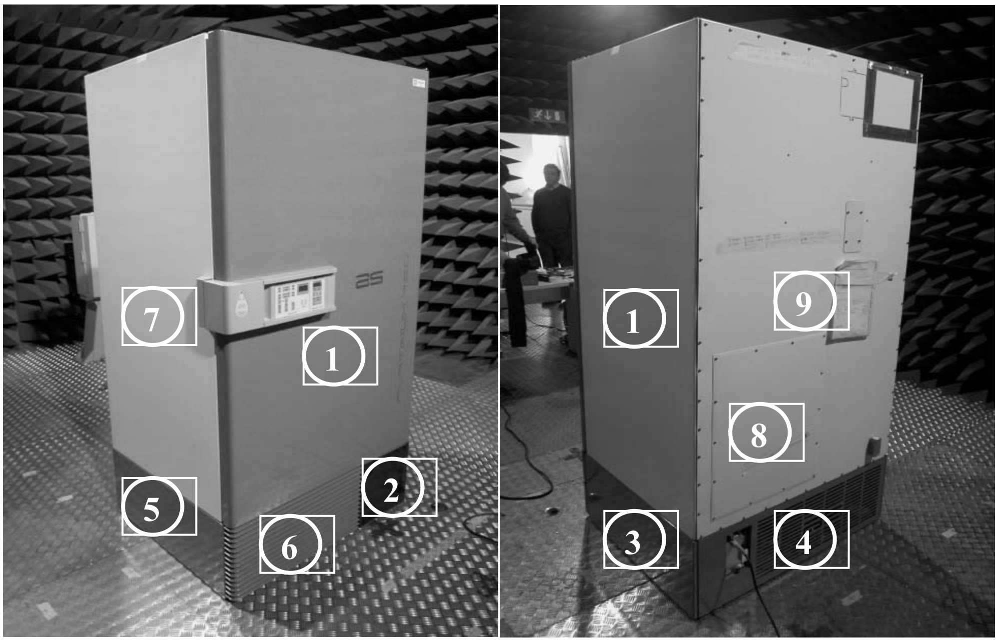

Figure 4: vibration levels measurement points

Highest acceleration levels occur for the lower measurement points (2, 3, 4, 5 and 6; see Table 1, BEFORE values). As an example, acceleration level spectrum relative to point 4 is reported in Figure 8 (BEFORE spectrum). Main vibration component is 63 Hz which corresponds to supply frequency (60 Hz). It is due to compressors which are placed in the freezer basement (see Figure 2). This very low frequency component is not individuated by the intensity measurements due to the methodology limits [3]. Thus, a sound pressure measurement campaign has been carried out in order to individuate if this component propagates itself into the surrounding environment.

ULTRA FREEZER SOUND POWER EVALUATION BY MEANS OF SOUND PRESSURE MEASUREMENTS

Noise pressure levels due to Platinum 750V have been evaluated by a measurement campaign into a hemianechoic room according to ISO 3745 [4]. Twenty measurement points have been individuated on a fictitious 2.5 m radium hemispheric surface which surrounds the noise source. Figure 5 shows the comparison between freezer sound power levels measured by intensity method (1) and sound pressure method (2). Comparison shows the following results:

- 1) method results are very close to 2) ones in 100–20k Hz frequency range (difference is less than 1.5 dB); 1) method results are considered more reliable than 2) method ones in 100-20k Hz frequency range. In fact, intensity measurements allow to take into account only noise components generated by the investigated source [3].

- A 63 Hz third-octave main noise component has been individuated by 1) measurements; this component is not individuated by intensity measurements due to this technique low frequencies limits [3].
- Global levels due to 1) method are higher than 2) ones because 1) methods allowed to evaluate exactly also very low frequencies spectrum levels. Global A-weighted power level measured by 1) method is very close to 2) one (very low frequencies measurement errors are attenuated by A-weighting curve filtering). A 6.1 dB difference occurs between measured linear levels.
- Power levels measured by 1) method are 79.4 dBlin and 69.7 dBA.

Platinum 750V power levels have been considered equal to:

- the ones obtained by 2) method for 20-80 Hz frequency range;
- the ones obtained by 1) method for 100-20k Hz frequency range.

Thus, Platinum 750V power levels are 79.2 dBlin and 69.0 dBA. Power spectrum is reported in Figure 9 (see BEFORE values).

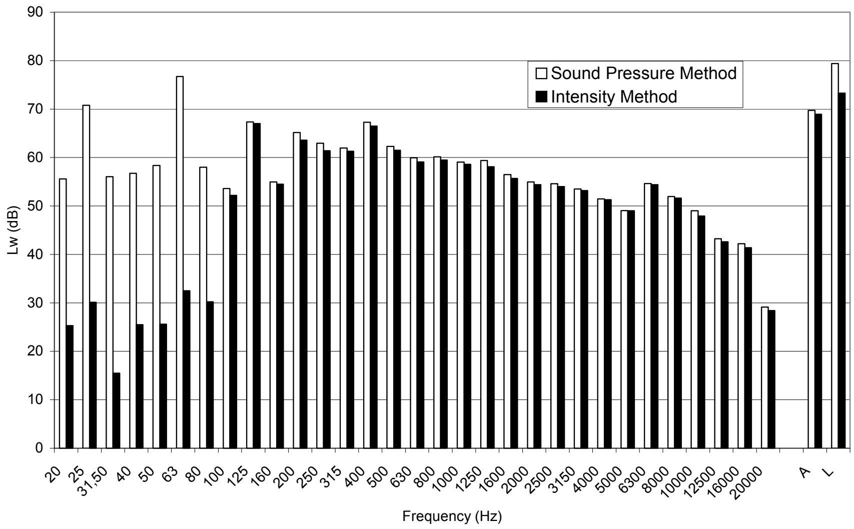

Figure 5: comparison between power levels measured by intensity and sound pressure methods

NOISE REDUCTION SOLUTIONS

Measurement results have shown that freezer main noise sources are fan and compressors. In particular:

- a 125 Hz airborne noise component is due to the fan;
- a 63 Hz solid-borne noise component due to the compressors.

Thus, the following noise reduction solutions have been proposed and realized:

a) Heat exchanger (see Figure 2) has been substituted with a larger one; thus, 1550 rpm has been replaced by two smaller 1300 rpm fans maintaining the same fluidodynamic performances;

b) Installation of a 1 cm thick anti-vibration polyethylene panel between the compressors-fan sledge and the freezer bottom plane [5];

c) Screws which connect the compressors-fan sledge to the freezer bottom plane are replaced by elastic junctions;

d) 1 cm thick polyurethane sound absorbing material is installed on freezer basement upper plane;

e) a resonant absorbing panel is installed on the sledge between fan and the compressors (see Figure 6); the panel is constituted by 30 mm thick glass wool covered by two holed elements at each side;

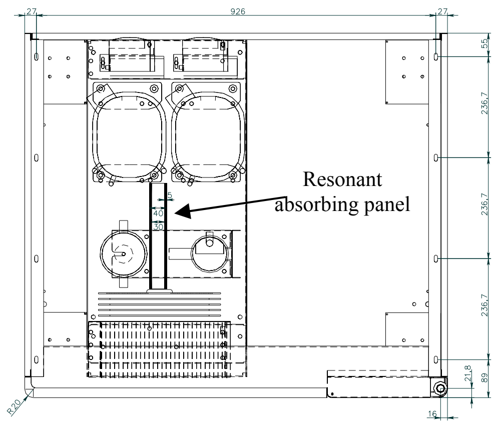

Figure 6: installation of a resonant absorbing panel between the fan and the compressors

f) Installation of porous sound absorbing material on the freezer basement front grid (see Figure 7).

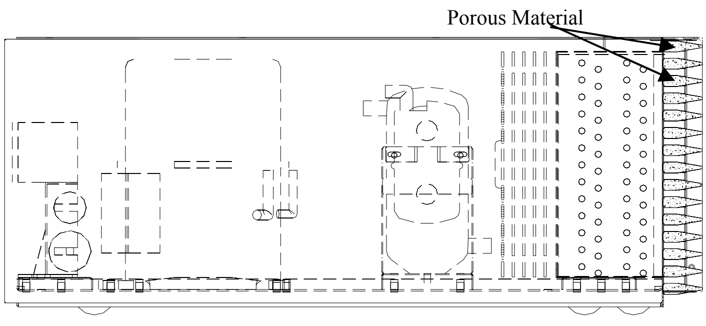

Figure 7: installation of porous material on the freezer sledge front grid

EXPERIMENTAL VERIFICATION OF THE PROPOSED NOISE REDUCTION SOLUTIONS

The proposed noise reduction solutions efficacy has been verified by repeating the previous vibration, intensity and sound pressure measurement campaign. The comparison between acceleration and sound power levels measured before or after the realization of the proposed noise reduction solutions is reported in Table 1 and Figure 8 and Figure 9. The comparison has shown that:

- high acceleration levels reduction is obtained for 2, 3, 4, 5 and 6 measurement points where the solid-borne noise is generated (average global reduction is 11.5 dB, average reduction for 63 Hz main component is 15.6 dB).
- Freezer measured power levels after the realization of the proposed solutions is 71.6 dBlin and 64.4 dBA; thus, a 7.6 dB and a 4.6 dBA noise power reduction has been obtained. Main noise component due to fans is 100 Hz for AFTER condition, 125 Hz for BEFORE condition; thus, a 100 Hz sound power increase occurred after the realization of the proposed solutions.

Table 1: comparison between global acceleration levels BEFORE and AFTER the realization of the proposed noise reduction solutions

Measurement Point	*Global Acceleration Level BEFORE Condition (dB)*	*Global Acceleration Level AFTER Condition (dB)*
1	104.0	102.9
2	119.6	107.2
3	130.2	114.7
4	132.4	121.5
5	128.2	119.3
6	118.2	108.1
7	101.5	100.8
8	119.6	106.5
9	101.2	100.1
10	101.2	100.9

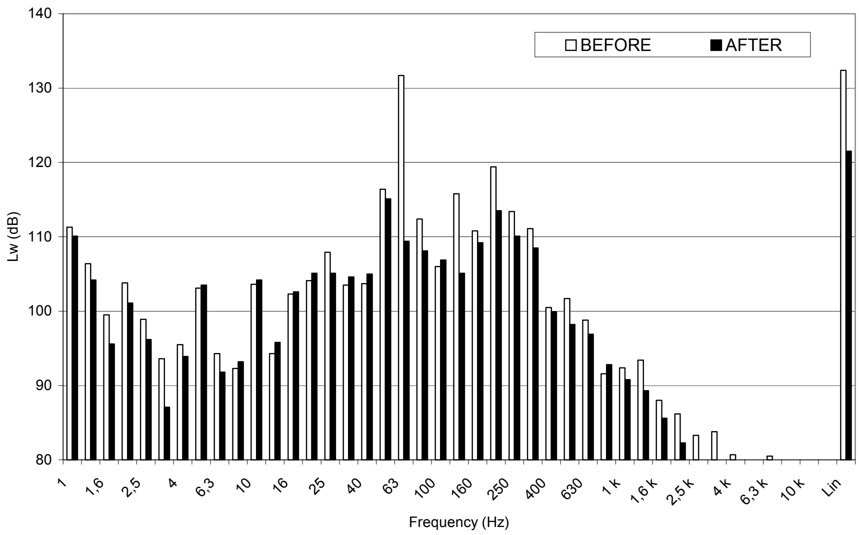

Figure 8: comparison between acceleration level spectrum relative to the measurement point 4 BEFORE and AFTER the realization of the proposed noise reduction solutions

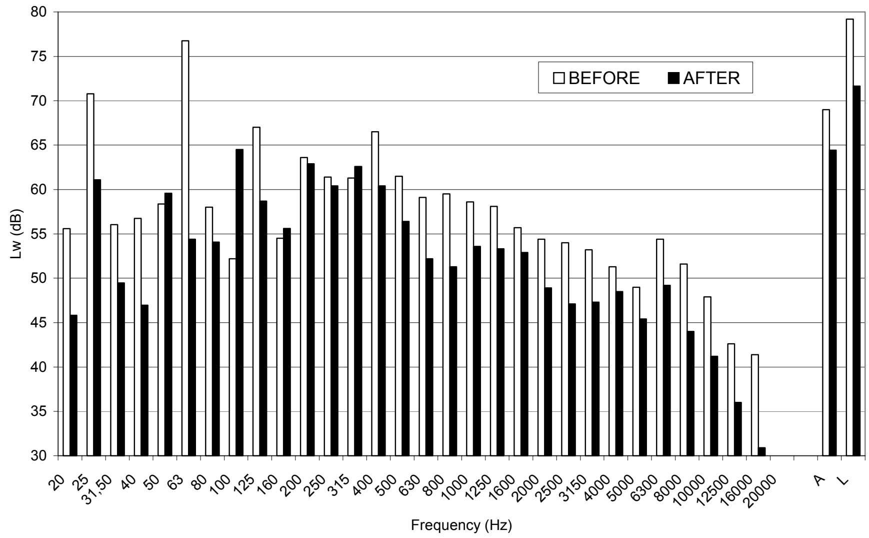

Figure 9: comparison between PLATINUM 750V noise power levels BEFORE and AFTER the realization of the proposed noise reduction solutions

CONCLUSIONS

Ultra Freezers acoustic characteristics have been investigated by intensity and sound pressure measurements on Platinum 750V by Angelantoni S.p.A. Measurement have shown that Platinum 750V global power level is 69.0 dBA and 79.2 dB. Main noise components are 63 Hz and 125 Hz: 63 Hz component is due to the compressors which are the main solid-borne noise source; 125 Hz component is due to the refrigerating fan which is the main airborne noise source.

Some noise reduction solutions have been proposed which consists on: the installation of anti-vibration and sound absorbing panels on the compressors-fan sledge; the substitution of the freezer heat exchanger with a larger one (thus, fan rpm is reduced). A measurement campaign has allowed to verify that average acceleration level reduction is 11.5 dB for the measurement points where solid-born noise is generated. A 4.5 dBA and a 7.6 dBlin global sound power reduction has been obtained by adopting the proposed solutions.

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