UTILIZATION OF SILENCERS TO REDUCE THE PERSONAL NOISE EXPOSURE IN WORK ENVIRONMENT

Ph.D. Mihai Costescu*; dipl.eng. Silviu Platon

Institute for Research and Development in Labour Protection, Bucharest, Romania

By principle of operation, there are two main categories of silencers: the active silencers and the reactive silencers. In this paper, the category of interest is that of active silencers, usually made as a duct lined with sound absorbing material, which is the main element for noise reduction. When the sound waves are spread in the sound absorbing layer, there are losses depending on the viscosity friction when the air is flowing through the material pores, the internal friction during the alteration of material structure, as well as on the heat exchange between the pores and the material structure. As the sound wave reaches the surface of sound absorbing material, the air flow is divided between different pores, being reduced to their sizes. Thus, the wave speed rises comparatively with the free wave speed, and the sound energy is effectively absorbed.

The active silencers may be used to reduce the noise of ventilation equipment, air conditioning device or other aero dynamical equipment as well as to occlude the holes in sound insulating enclosures or cabins, to allow the air intake without impair the sound insulation performances.

The authors considered this category, because the great importance of such a silencer efficiency. A sound insulating cabin or enclosure without a silencer or with a silencer of low efficiency mounted in the ventilation holes (those that allow the air flow to obtain optimum exchanges for workers or to cool the machines enclosed) becomes on ineffective solution for noise reduction, however the structures of cabin or enclosure walls are efficient from de point of view of their sound insulating properties.

The authors present three types of active silencers, sized to be used in the cases presented above, namely to be mounted in the ventilation holes of the sound insulating cabins or enclosures.

One of the common research directions for a laboratory of Noise and Vibration Control is the category of general solutions for diminishing the noise effects at work places, solutions with a wide range of applications in different professional areas.

This category contains the sound insulating cabins and enclosures. The first is intended to protect the receiver (worker), providing him a low noise work place, implicitly a daily noise exposure low enough to prevent the occurrence of occupational loss of hearing.

The second of the general solutions mentioned above is intended for the emitter. Usually, the sound insulation enclosures achieve the sound insulation of strong noise sources (machines) so that the acoustic energy radiated in the nearby work environment induces a safe daily noise exposure (in accordance with the General Rules for Labour Protection) for the workers operating the machines.

In both cases, almost always the assurance of air circulation is needed. Obviously, for the sound insulating cabins it is the inner air which has to be breathable, by natural circulation of the air or by means of ventilation equipment (forced circulation).

At the sound insulation enclosures, there is a normal temperature increase near the technical equipment, which needs a cooling device, in most cases with air, so the possibility of communication with the outside part of the enclosure.

The almost compulsory existence of those ventilation holes in the case of the two general solutions considered for noise control may produce a strong diminution of the acoustic efficiency if the ventilation holes are not provided with silencers.
The silencers are active silencers and reactive silencers, depending on the operation principle. The most interesting category for this paper is that of active silencers, usually made as a duct lined with sound absorbing material, which is the main element for noise reduction.

When the sound waves are spread in the sound absorbing layer, there are losses depending on the viscosity friction whenever the air is flowing through the material pores, the internal friction during the alteration of material structure, as well as on the heat exchange between the pores and the material structure. As the sound wave reaches the surface of sound absorbing material, the air flow is divided between different pores, being reduced to their sizes. Thus, the wave speed rises comparatively with the free wave speed, and the sound energy is effectively absorbed.

The active silencers can be used to reduce the noise of ventilation equipment, air conditioning device or other aero dynamical equipment as well as to occlude the holes in sound insulating enclosures or cabins, to allow the air intake without impairing the sound insulation performances.

The authors considered this category, because of the great importance of such silencer efficiency. A sound insulating cabin or enclosure without a silencer or with a silencer of low efficiency mounted in the ventilation holes (those that allow the air flow to obtain optimum exchanges for workers or to cool the machines enclosed) becomes an ineffective solution for noise reduction, however efficient the structures of cabin or enclosure walls are from de point of view of their sound insulating properties.

Therefore, there were designed several types of silencers to be used in the cases presented above. Thus, there were designed the model of a simple silencer, without baffles (a duct lined on three sides), the model of a silencer with straight baffles and the model of a silencer with angular baffles.

Since the model of a simple silencer was designed in two versions, four experimental models of silencers were tested.

The sound insulating cabin which was used for testing the experimental models of active silencers is a typical cabin for surveillance of work processes, having a large number of windows (figure 1).

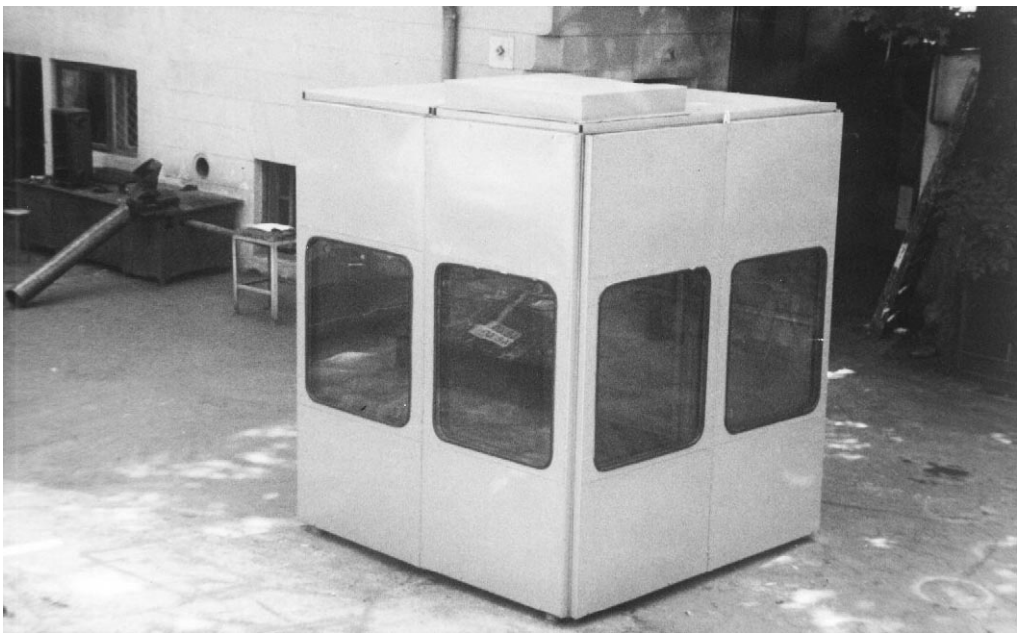

Figure 1 – Sound insulating cabin
- *4 modules „panel with windows”*
- *1 module „ceiling panel with cu ventilation hole”*
- *1 module „ceiling full panel (without holes)”*

The sound insulating cabin has the dimensions 2500 × 2500 × 2900 mm, being made by assemblage on the cabin frame of several modules (panels) as follows:

- panel with window
- panel with door
- full panel (without holes)
- panel with ventilation hole.

The experimental models of tested silencers were mounted on the last type of panel – the panel with ventilation hole.

For tests made in the Laboratory of Acoustics of the Mechanics Department in the Polytechnic University – Bucharest, the measurement of the attenuation obtained for the four experimental models of active silencers used an electro acoustic chain consisting of a Brüel & Kjaer sinusoidal sound generator, a power amplifier, an Brüel & Kjaer omni directional sound source, and a Brüel & Kjaer precision sound level meter.

For testing the regime of the sound generator was wide band random noise (white noise). It presents the advantage of measuring a total value for the sound pressure level L as well as for the A weighted sound pressure level L_A, since the safety and health work expert is mostly interested in daily noise exposure of workers

(in other words the most important thing is the noise reaching the worker's ear every day, what he actually "hears".) The analysis of results of determinations was made taking into account the total values obtained for the A weighted level, L_A, in dBA, having in view the fact that the A weighted sound pressure level, L_A, accounts for the subjective impression of the human hearing perception.

There were recorded the following attenuations, obtained with the same cabin panel with ventilation hole and equipped with different experimental models of active silencers:

- panel with simple silencer (version A) - 36 dBA
- panel with simple silencer (version B) - 27 dBA

  The difference between the two versions appears because the length of the silencer (in the version A the length is twice the one in version B), the others constructive characteristics (the structure, the material, the dimensions) being the same.
- panel with silencer with straight baffles - 38 dBA
- panel with silencer with angular baffle - 39 dBA.

The result analysis shows the following:

- all the experimental models of tested active silencers present a very good acoustic efficiency of the sound insulating cabin for which they were designed;
- the lowest performances were obtained for the simple silencer, although, even in this case, the increasing of silencer length (version A) results in a performance improving, approaching the values obtained for the silencers with baffles;
- the increasing of attenuation obtained when the straight baffles are replaced by angular baffles is not significant and does not justify the supplementary costs and difficulties of construction which that replacement implies;
- the cabin panel with ventilation hole and equipped with the most competitive experimental models of silencers results in attenuations similar to the other types of panel which the cabin is made from, as follows:
  - panel with window - attenuations of 39…40 dBA;
  - panel with ventilation hole equipped with silencer - attenuations of 36…38 dBA;
  - full panel - attenuations of 33…35 dBA;
  - panel with door - attenuations of 32 dBA.

Obviously, the use of sound insulating cabins equipped with active silencers as those designed and experimented in this work assures the necessary efficiency from the acoustic point of view. The conclusion is also valid in the case of the sound insulating cabins with normal circulation of cooling air, for which the family of active silencers proposed and verified by the authors can be used.