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ACOUSTICAL CONDITIONING OF A LOCOMOTIVE LOAD TEST FACILITY

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ABSTRACT
Studies concerning the acoustic impact of moving trains are often to be found in the literature. Stationary trains, however, are seldom a matter for concern. The present work addresses an important exception, namely: a rail manufacturing and maintenance facility. Locomotive testing facilities may operate at any time, to carry for specific production needs, and are normally situated inside regions where acoustic related complaints might be critical. The present work describes the acoustic evaluation carried out in one of these facilities, located inside an industrial area, with restricted noise limits. A set of typical results is shown and used as a basis for the presented wide spectrum noise control solution. Operational and safety conditions are also considered, as well as atmospheric contaminants removal. The adequacy of the proposed solution shall be experimentally evaluated in a future research work.

1 - INTRODUCTION
Trains may be a major source of noise in urban regions, where paradoxically they are essential to improve living standards. It is therefore not surprising that a lot of research and design effort has been dedicated to this problem. Underground and city trains have been studied, as well as long distance trains [1], [2]. These studies consider mainly two classes of problems, namely: the noise perceived by train occupants and that felt by people or houses situated nearby the rail lines. The majority of these studies considers the effects produced by trains moving from one place to another. Fixed manufacturing and testing installations, on the other hand, have been less studied, even though they may produce very high noise levels, and can be extremely troublesome, as they may operate at any time, very often during the whole evening and early morning hours. The problem has recently become more serious as in recent years industrial areas are becoming closer to residential areas.
Locomotives are clearly the most important noise source, whether alone or in stationary compositions. It can also be said that from a noise control point of view, testing and manufacturing facilities are very similar to any other industrial installation. However they also present some peculiarities, mainly concerned with wide variations of equipment dimensions, and of operational/testing conditions. The present text considers a locomotive testing facility, located inside the industrial area of a large town, and the associated noise control design.

2 - THE NOISE PROBLEM OVERVIEW
The industrial installation being considered is located for obvious reasons close to a major access highway and next to a train station which is regularly used by heavy goods trains. The region is reasonably flat, without any major obstacles, and the surrounding industrial buildings are all low in height. The original installation was being regularly used for the test of diesel-electric locomotives right after manufacturing or major overhaul. This original facility offered essentially only shelter from the rain, but hardly any environmental control resources. Even the control cabin located next to the testing facility proved to

be inadequate for some of the testing conditions. The present study originated from a decision of the operator to improve operational conditions.

The main noise source can be clearly associated with stationary locomotives when they are operating inside the testing area. The contribution of moving cargo trains can also be observed but it is not a major problem, not only because of operational variables, but also because traffic is infrequent during the night and early morning hours.

Diesel-electric locomotives noise sources can be conveniently organized according to the following classification: rolling and braking sources, electrical system sources, compressed system sources and aerodynamic noise sources. For stationary railway engines neither the latter nor the rolling and braking sources need to be considered. The noise associated with structural vibration becomes more perceptible, even though it may not necessarily be a matter of concern for any operational condition. The present study has confirmed that the main source of noise is the diesel engine, when the other systems are well adjusted. The authors have confirmed improper adjustments may introduce additional high noise levels. This is the case, for example, of the compressed air system, which may produce very high noise outputs, a condition which the authors have observed to be amplified by coupling effects taking place between the compressed air system and the surrounding steel plating structure.

3 - ACOUSTIC MEASUREMENTS PROCEDURES

Acoustic measurements were carried out by means of two sets of procedures, namely: measurement of the average sound pressure levels and measurement of the spectral distribution. A mesh of containing 55 points was used in the evaluation, the number of points, the geometry of the mesh, and the procedure defined according to the authors' experience, as defined for example in [3]. Pertinent ISO standards and state legal requirement have also been observed. A precision microphone coupled to portable computer (notebook) provided with data acquisition hardware and software was employed as an FFT analyzer. Portable SPL meters were also used. The procedure was repeated during different days at different day times and comprised whole testing area, which included the existing control cabin, and the neighboring areas.

The measurements were carried out essentially for three stationary railway engine conditions, namely: idle, maximum rotational speed without load, and full throttle at maximum rotational speed with full load. Each condition corresponds a particular (limit) operational condition. Also they enable the evaluation of separate contributions, that is: compressed air system, diesel engine, and electric generator contributions. Temporal variations have not been observed, and therefore considerations about the measurement lengths of time are not applicable.

4 - CONSIDERATIONS ABOUT THE OBTAINED RESULTS

Figure 1 indicates the sound pressure level distribution in the test area for a typical condition, i.e., full power, full rpm for a 4000 HP locomotive. The spectral distribution for a measurement point close to the locomotive is also shown. Since the locomotive is not moving, a simulated load composed of resistors was couple to the output electric generators during testing. The black rectangle indicates the designated testing area, limited at the right hand side by the dividing wall existing between the installation and the railway line. The control cabin and the dummy load positions are also indicated.

The obtained SPL values are well above that allowed by the pertinent legislation (state of Minas Gerais ordinance No. 10100, January/1990) which establishes a limit of 70 dB(A) for day time, and a limit of 60 dB(A) for the night. The obtained spectrum for other positions and loading conditions is basically very much the same. This corroborates with the consideration that the most important noise source is the diesel engine. It is important to observe that other authors such as [4] present a similar spectrum distribution for a locomotive. The peak corresponding to the octave centered at 125 Hz corresponds to the noise emitted by the diesel exhaust [5], which is again a confirmation for the previously described condition. Finally it is interesting to observe that a detailed study of the spectral distribution can also provide additional insight into the other noise sources.

5 - THE DESIGN SOLUTION

Appropriate consideration of the previously described situation led to the conclusion that an attenuation of 50 dB had to be provided for conditions comprising a very wide spectrum. Noise control measures only based on the so-called "mass law" would have resulted in excessive material consumption, as absorbing materials are not very effective in the low frequency range. Also a 4000 HP diesel engine produces heat, toxic gases and fumes, which have to be removed, using an exhaust system itself produces a considerable noise. A combined solution was therefore adopted, employing material absorption, Helmholtz resonators

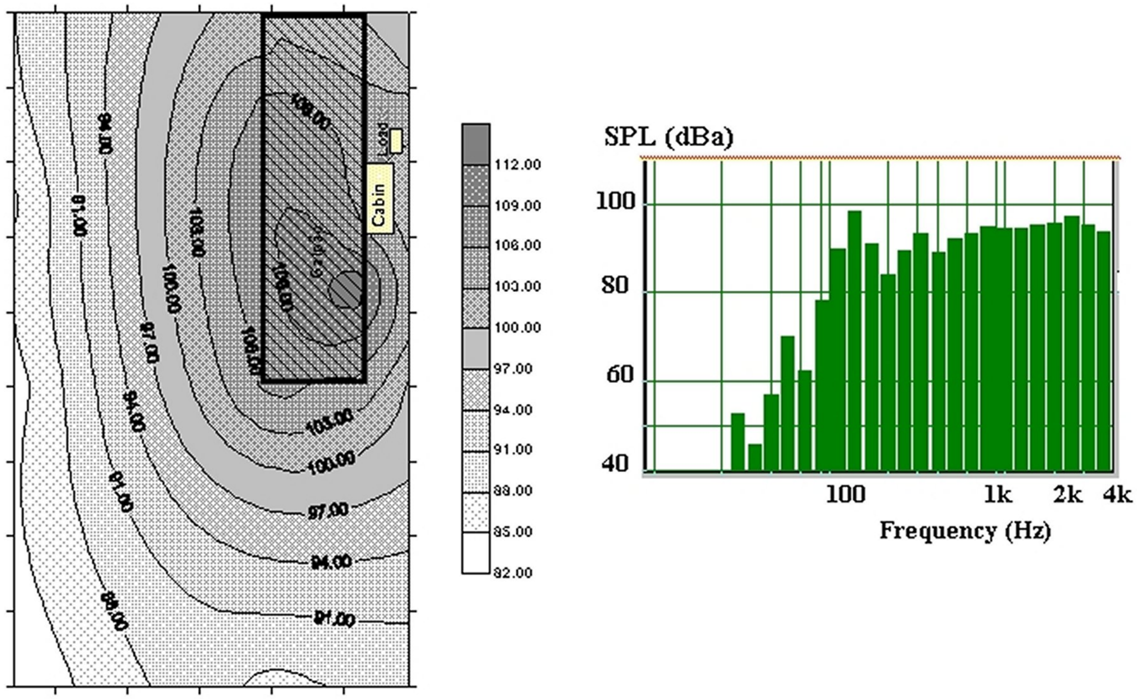

Figure 1: Typical sound pressure level and spectrum distribution at the testing facility.

tuned to reduce diesel engine and exhaust system noises, a suspended roof, and the installation of floating panels over the double masonry/mineral wool wall. Figure 2 shows some of the details of the proposed design solution.

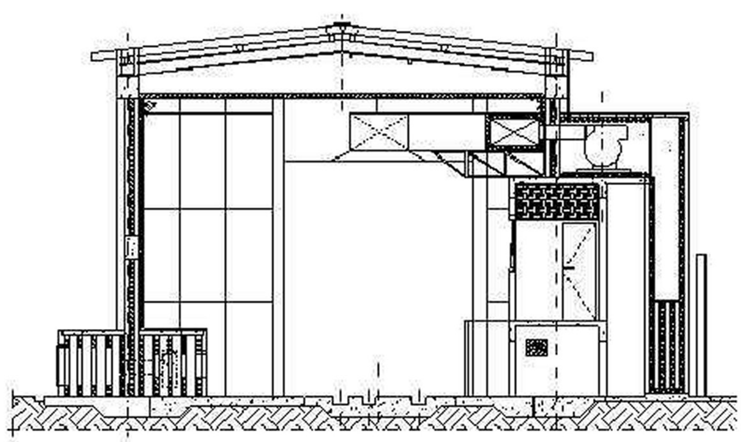

Figure 2: Details of the design solution employed in the test facility.

6 - FINAL CONSIDERATIONS

A locomotive testing facility producing high levels of output noise has been investigated. This study enabled the characterization of noise sources which has resulted in the design of the noise control solution, which has also considered the exhaust system for the testing facility. Civil construction of the designed installation is now being undertaken, and its efficiency shall be evaluated upon completion in the very near future.

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