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MEASURING AND CONTROLLING OF NOISES AND VIBRATIONS GENERATED BY INDUSTRIAL SOURCES

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ABSTRACT

This paper describes a methodology for measuring and control of noises and vibrations generated by industrial sources, such as: construction activities, equipments which use vibrations into working process, etc. The theoretical and experimental researches on this study were supported and developed within the National Framework Research Programs CNMP–INFOSOC CeEx 110/2006. European legislation (e.g. Directive 2002/49/EC and 2002/44/E) imposes on our country a permanent monitoring of the vibrations and noises which must offer available informations to decribe their map. Finally, the authors proposed a tool for aquisition, processing and management of vibration and noise data.

KEYWORDS: measurement, virtual instrument, industrial noise, vibration

1. VIBRATION AND NOISE SOURCES

Noise and vibration are traditionally linked in environmental impact assesements because both are perceived to have many physical characteristics in common. For exemple, noise can be generated by vibration of surfaces. Both involve fluctuating motion: noise is oscillating motion of air and vibration is oscillating motion of structures of the ground, as it can be seen in fig. 1.

Vibrations and noises can be caused by many different internal or external sources, including industrial, construction and transportation activities .

The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). Examples of typical types of vibration and their sources are:

- *Continuous vibration*: Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery);
- *Impulsive vibration*: Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading;
- *Intermittent vibration*: Trains, nearby intermittent construction activity, passing of heavy vehicles, forging machines, impact pile driving, jack hammers.

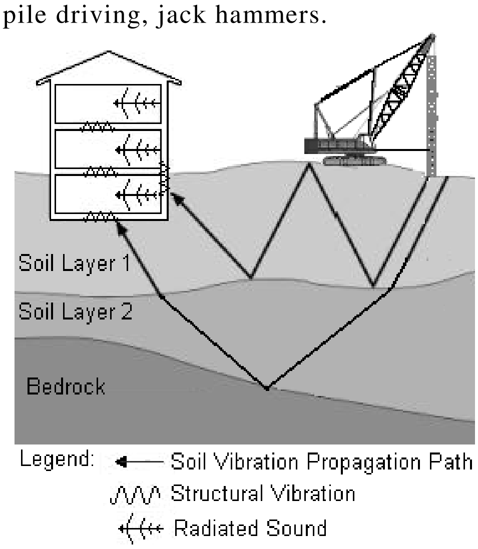

Figure 1. Propagation of ground vibrations into buildings

Vibrations and noises in industry, in the work place and in the community can potentially degrade quality of life [1], [2]. Permanentlly monitoring the vibrations and noises generated by the industrial sources (see fig. 2) offers available informations regarding the vibration and noise level and is helpful to decribe their map, according to the Directives 2002/49/EC and 2002/44/EC [5], [6].

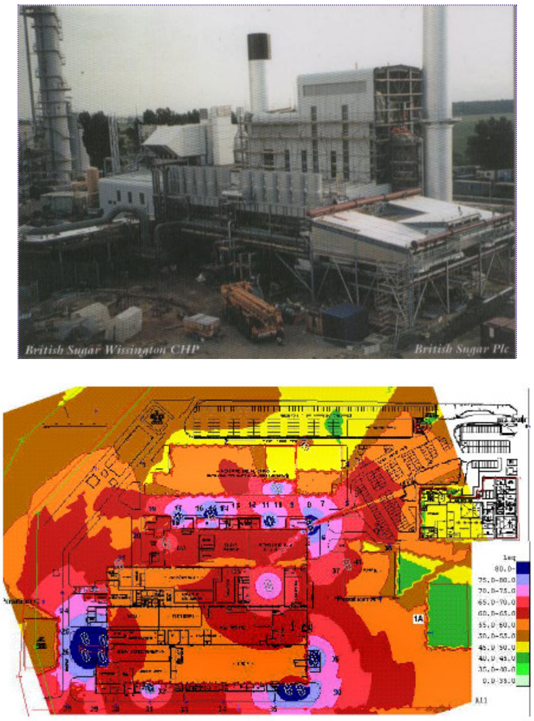

Figure 2. Exemple of noise map factory

2. THE VIBRATION AND NOISE IMPACT CRITERIA

Vibration velocity level, in decibels, is defined as:

$$L_v = 20 \cdot log_{10}\left(\frac{v}{v_{ref}}\right) \quad (1)$$

where L_v is the velocity level, in decibels
v – the rms velocity amplitude
v_{ref} – the reference velocity amplitude.

Two main indicators are used for noise assessment: L_{den} and L_{night}.

The day-evening-night level L_{den} is defined by the following equation [8]:

$$L_{den} = 10log\frac{1}{24}\left(12\cdot 10^{0.1\cdot L_{day}} + 4\cdot 10^{0.1\cdot(L_{evening}+5)}\right) + 10log\frac{1}{24}\left(4\cdot 10^{0.1\cdot(L_{night}+10)}\right) \quad [dB(A)] \quad (2)$$

where:

L_{day}[dB(A)] is the A-weighted long-term average sound level determined over the day periods of a year;

$L_{evening}$[dB(A)] – is the A-weighted long-term average sound level determined over the evening periods of a year;

L_{night}[dB(A)] – is the A- weighted long-term average sound level determined over the night periods of a year, in which:

a) the day is 12 hours, the evening 4 hours and the night 8 hours;
b) the default values of the start and end of the day (night, evening) are 7-19.

3. DESCRIPTION OF MEASURING AND CONTROL SYSTEM

For optimal achievement of real time vibration/noise measurements which affect habitation area by the industrial sources, it was necessary to impose the following considerations:

- distance measured from the vibrations/ noises source to the interest point is arround 100-200 metres;
- vibrations frequency band is 0-20 Hz and for noises is 0-10 kHz.

From an economic point of view, in order to achieve vibration/noise monitoring two stages are necessary:

- the establishment of the theoretical model for vibrations/noises propagation on the affected area, through the acquisition of distributed data system, with many sensors situated near the signal sources and at different receiving points and synchronization acquisition data focused only at server. Finally, through processing of database, a theoretical model will be realised;
- in real-time vibrations/noises monitorization through emplacement of a reduced number of sensors in the interest area, transmission of synthetized information to server and vibrations/noises propagation prediction at totality affected area, based on the established theoretical model.

The device used to measure vibration and noise levels is composed of a microphone and a vibrations transducer such as an accelerometer. These are chosen in function of the type of noise and vibration sources.

The monitoring system of vibrations and noises, proposed by the authors has the following configuration [11], [12]:

- vibration transducers of 4506B003 B&K triaxial accelerometers type, (fig. 3a)

- 8340 B&K uniaxial accelerometer, (fig. 3b)
- 4188A021 B&K microphon, (fig. 3c)
- multi-analyzer system by PULSE B&K, 3560B type, with B&K Pulse LabShop software version 12.5.0, (fig. 4)
- portable notebook and interface cables.

a. b. c.

Figure 3. Transducers
a. Triaxial accelerometer; b. Uniaxial accelerometer c. Microphone

Figure 4. Acquisition and processing data system

Acquisition data was storaged in a portable computer and transfered into database on central server. For transfering data at long distances it is very convenient to use the Ethernet connections. When this thing is not possible, for short distances (<100m) wireless transmision is recommended and for long distances it is right to use the modem GSM/GPRS. The monitoring system was tested through indoor and outdoor essay with artificial vibration and noise sources and through "*in situ*" experiments with real vibration and noise sources [7].

4. MEASUREMENT METHODOLOGY

If possible, it's useful to determine the maximum distance at which noises and vibrations are propagated. The calculus relation of the minimal distance R_1, face to the sources is [10]:

$$R_1 = 0.5a + \lambda_R \qquad (3)$$

where a represents the source dimension measured in parallel with the waves propagation direction; λ_R - the wave lenght of the surface wave (Rayleigh).

The distribution of the measuring points looks like a radial network, as it can be seen in fig. 5.

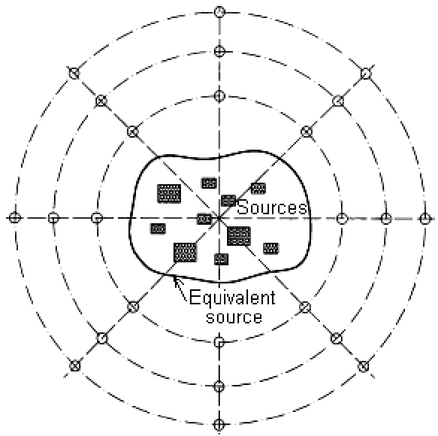

Figure 5. Measuring points emplacement

When the interest area is unhomogene – it presents hollow or upheaval terrain, overground and underground buildings, etc. – then the network will have much more measuring points, for a realistic description.

The place where the monitoring points are situated is as much possible on an homogeneous terrain and on the direction of more affected area points (factory, buildings, agglomeration places, etc.). The transducer should be orientated as recommended by the manufacturer in the direction of the vibration source thus: seismical accelerometer on vertical direction and microphone on horizontal direction. The transducer should be located at a sufficient distance from any structure so as to avoid undue interference from vibration "feeding back" from the structure. The required distance away will be specific to the site and structure and would need to be determined for each case (never less than 3.5m by any reflector structure), acording to ISO 4866:1994 and ISO 8569:1996 standards.

The height of the assessment point depends on the following applications:

- in the case of computation for the purpose of strategic noise mapping in relation to noise exposure inside and near buildings, the assessment points must be 4.00 ± 0.2m abouve the ground;
- in the case of measurement for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, other heights may be chosen, but they must never

be <1.5m above ground and results should be corrected in accordance with an equivalent height of 4m;
- in case of acoustical planning and noise zoning other heights may be chosen, but they must never be < 1.5m above ground.

In the study case (e.g. environmental area is affected by a vibratory hammer), the measurements are simultaneously effectuated into three points situated on the circle arc, as see in the fig. 6.

Figure 6. Measuring units emplacement

Figure 7 shows the frontal panel of the virtual instrument used for acquisition, processing and management data.

Figure 7. Working panel of virtual instrument

For a systematic presentation, the vibration/ noise survey reports for a typical industrial source should contain the next informations:
- description of the machine and its conditions of installation and operation
- position of measuring points
- land-use and environment description
- person who effectuates the measurements
- number of readings
- weather conditions
- information about reading values (X, Y and Z coordinate) and noise
- the moment when measurements and database processing time
- reference to individual standard(s)
- description of the measuring apparatus used and the method of calibration
- vibration/noise level results and frequency spectrum.

4. CONCLUSIONS

As concluding remarks it could be mentioned the followings:
-the real tests reveal the importance of the noise and vibration measuring near the very pollutant sources;
-the instrumental „*in situ*" tests were a validation of computing simulations, and provide additional data for instrumental system tunning and for development of the final measuring unit.

One of the major conclusion deals with the Implementation of the Environmental Noise and Vibration Directives at the National and local level and harmonization of the National laws with the European laws in the area of environmental noise and vibration management and evaluation.

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REFERENCES

[1] **N. Dragan** *Some considerations about noise pollution and the work-related health diseases*, Constanta Maritime University Annals, Year IX, vol. 11, 2008
[2] **N. Dragan** *The impact of occupational noise on the workers. Romanian and EU legislation*, The Annals of "Dunarea de Jos" University of Galati, Fascicle XIV Mechanical Engineering, ISSN 1224-5615, Galatzi, 2007
[3] **G.-R.**, **Gillich**, **C. Chioncel**, **O. Vasile**, **S. Nastac** *Vibration monitoring of industrial plants*, The Proceedings of the Intern. Conf. "Actual Problems Regarding The Urban Acoustics", Romanian Society of Acoustics, Bucharest, 2007, ISSN 1584-7284
[4] **A. Leopa**, **S. Nastac**, **V. Kolumban**, **C. Debe leac** *Poluarea vibratorie produsa de echipamentele tehnologice cu actiune impulsiva*, Al XIII-lea Simpozion National de utilaje pentru constructii, SINUC 2007, Bucuresti, dec. 2007, ISSN-1842-6352.
[5] **S. Nastac** *About the Vibration Map Achievements for the Intensive Pollution Zones*, The Proceedings of the IX-th Symposium "Acoustics and Vibration of Mechanical Structures - AVMS 2007", Academia Romana, 2007, ISSN: 1843-0902, pg. 54.
[6] **S. Nastac** *The virtual instrumentation utilization on acquisition and processing of vibration map data*, The Proceedings of the Intern. Conf. "Actual Problems Regarding The Urban Acoustics", Romanian Society of Acoustics, Bucharest, 2007, ISSN 1584-7284
[7] *** CNMP- INFOSOC CeEx 110/2006
[8] *** Directive 2002/49/EC
[9] *** Directive 2002/44/EC
[10]***DIN 4150-1:2001 Vibration in building - Part 1: Prediction of vibration parameters.
[11] *** LabView User Manual, National Instruments, 2003
[12] *** National Instruments company website: URL: http://www.ni.com