CONTROL AND IMPROVEMENT OF THE EXPLOITATION AND RESTORATION CONDITIONS IN OPENCAST MINING OF THE AUTONOMIC COMMUNITY OF THE BASQUE COUNTRY

Cristina Avilés González and Alfonso Sánchez Conejo

Mining Engineering, Metallurgic and Material's Science Departament. University of the Basque Country
Colina de Beurko s/n
48901 Barakaldo,Vizcaya, Spain
Phone: + 94 438 5608, Fax: + 94 437 5747
e-mail: iipavgoc@lg.ehu.es

ABSTRACT

In the quarries placed next to villages, exits a great sensibility due to the impacts that it may cause to the people and to the environment.

The projects here exposed are the result of an agreement between the Basque Government and the municipal government of the villages affected, with the objective of measure and control the activities of five quarries located in Güeñes, Mañaria and Rigoitia (Vizcaya).

The main objectives of the projects are:

- *Measure and control of vibrations and air blast caused by each rock blast produced in the quarries.*
- *Measure and control of the dust produced in the exploitation works.*
- *Analysis and control of the impact caused over the surface water and groundwater.*
- *Measure and control of the sound levels.*
- *Control of the exploitation and restoration works.*
- *Improvement of all the exploitation works that may cause negative environmental impacts.*

After two and a half years working in the projects, they have revealed like a useful and effective tool to control and determine the environmental impacts, and to induce the mining companies to attend the environment, and therefore, reduce in a substantial way the social alarm.

BACKGROUND

In the C.A.P.V. there are several opencast exploitations near to inhabited centres. In these villages, and derived from exploitation works, posterior treatment of raw materials and associated mine-siderurgical industries (concrete and cement factories) there is a high social awareness for the possible damages these could cause both to the environment and people.

The Basque Government, through the *Departamento de Industria, Comercio y Turismo* (Department of Industry, Trade and Tourism), and paying attention to the demands of the Town Councils involved, has signed a collaboration agreement in order to control the exploitation and restoration works, and the possible damages to the environment.

As a result of this agreement, the Councils of Mañaria, Güeñes and Rigoitia (Vizcaya), together with the *Departamento*

de Ingeniería Minera y Metalúrgica y Ciencia de los Materiales de la Universidad del País Vasco (U.P.V./E.H.U.) (Department of Mine and Metallurgical Engineering and Materials Science of the University of the Basque Country), agreed that this latest will carry out the control, follow-up and optimisation projects of the extractive industrial activity existing within these municipal areas.

The quarries object of these projects are located in Vizcaya, within the municipal areas of Mañaria, Güeñes and Rigoitia.

In Mañaria, there exist three quarries named: Markomin-Goikoa, Mutxate and Zallobenta, for lime extraction. Not only is Mañaria an area of great landscape interest, but also of rich flora and fauna, located in the boundaries of Urkiola Natural Reserve. It has to be underlined that the quarries of Mutxate and Zallobenta directly border on this Natural Reserve. In Güeñes, there is an exploitation called Andaroleta.

These four exploitations extract limes which are marketed as dry goods for construction industry, public works, siderurgy, cement industry and concrete manufacturing.

In Rigoitia, it is located the exploitation named Ofitas de Rigoitia, for the extraction of sub-volcanic rocks, marketed as dry goods too.

These projects were initiated in November 1996 and will conclude in April 2001.

AIM OF THE PROJECT

The principal aims of this project are the following:

- Measuring and control of vibrations and air blast originated by the blasting of quarries exploitation.
- Analysis and control of the impact on surface and underground water.
- Follow-up of the programmes of works carried out by exploiting companies in compliance with the Exploitation Project, Works Plan and Restoration Project.
- Measuring, control and minimization of atmospheric contamination.
- Measuring, control and minimization of acoustic contamination.

Measuring and control of vibrations and air blast

For controlling vibrations and air blast two instruments are used; the first one is a Blastmate, series II, model DS-477 and the second equipment is a Multiseis V.

As prevention criterion for damages caused by vibrations, it is used the norm UNE 22/381/93. It has been selected for being the criterion in force in Spain, and because it is specific for measuring possible damages caused on structures laying on ground or rock. According to this norm, the safety levels for the peak value of the main vibration component, measured in the land and depending on the main frequency and the type of structure, are the ones indicated in Table 1.

		Main frequency (Hz)		
		2-15	15-75	>75
		Speed (mm/s)	**Displacement** (mm)	**Speed** (mm/s)
Type of structure	I	20	0.212	100
	II		**90.095**	**45**
	III	4	0.042	20

Table 1. Safety levels according to norm UNE 22/381/93.

The types of structure are classified by the norm as recorded in Table 2.

Group I	Light industrial buildings and bays with reinforced concrete or metallic structures.
Group II	Buildings for housing, offices, commercial and entertainment centres, complying with the legal regulations in force. Buildings and structures with architectonic or historic value which, due to their strength, do not have special sensibility to vibrations.
Group III	Structures with architectonic or historic value which have special sensibility to vibrations by themselves or by the elements they contain.

Table 2. Types of structures according to norm UNE 22/381/93.

It has been considered that the total of buildings in the surroundings of the quarries are included in Group II.

The norm with values for safety levels for speed and frequency and with the types of structures defined appear in the chart of Figure 1.

As a prevention criterion of damages for air blast, the limit values proposed by Siskind and Summers (1974) are followed, which are deeply used in these kind of studies, and that are detailed in Table 3.

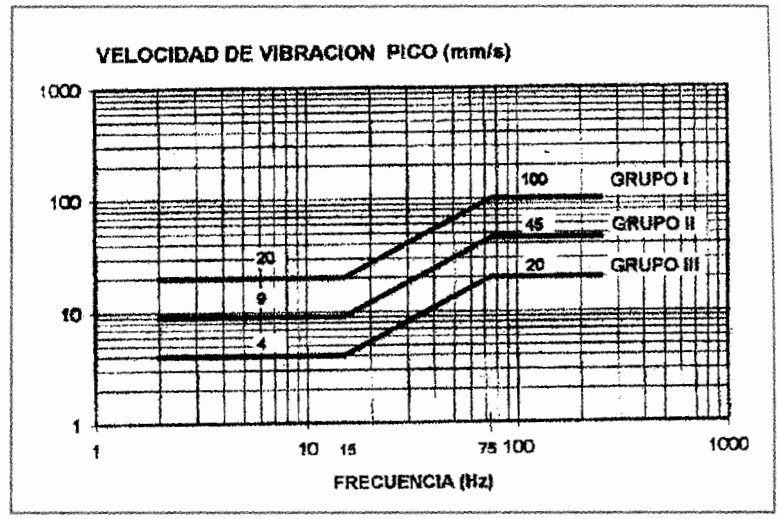

Figure 1.

	NOISE LEVELS		
	Linear peak dB (L)	C-peak dB (C)	A-peak dB (A)
Safety level	128	120	95
Precaution level	128 a 136	120 a 130	95 a 115
Limit level	136	130	115

Table 3.

It has to be underlined that, apart from the aforementioned adopted prevention criteria for damages, in the quarries of Mutxate, Zallobenta and Andaroleta, the Declaration of the Impact on the Environment establishes specific prevention criteria for each of these quarries, so they have had to be taken into account for control and measuring works.

For air blast, the weighting L has been selected , for it is the most adequate to evaluate the possibility of structural damages.

As measuring points, it has been used rock outcrops of the lithological units, exploitation object of the quarries. The existence of repeated complaints and denunciations issued by the inhabitants of the surrounding areas of the measuring points have been a decisive factor for the selection of the measuring points, apart from the technical factors.

With regard to the records obtained with each blasting, the measuring instruments place automatically the values for peak speed and frequencies above the chart of the norm UNE 22/381/93. The speeds of the several peaks recorded by the geophones and the frequencies corresponding to these peak values are calculated by the central unit, through the half period method and the analysis of Fourier.

Regarding the air blast, noise level is measured in dB of the corresponding balance.

The record obtained with each blasting is analysed together with its parameters: distance of the blasting to the measuring base, stope height, diameter, length and inclination of the holes, number of holes, nominal stone, effective stone, nominal spacing, effective spacing, calking, overdrilling, instantaneous maximum load, blasting total load and summary of the ignition sequence.

From the joint analysis of the records obtained and from the information of the blastings, the conclusions on the made measurings are elaborated, emphasizing the possible effects observed (discharges, gas leaks through the holes, etc.).

From January 1998, at the same time the vibrations and air wave are recorded, we have began the filming of the blastings in order to obtain more information, both qualitative and quantitative, that can be useful for the optimisation of blastings.

Analysis and control of the impact on surface and underground water

It has to be emphasized that the quarries are located in lithological levels with a high degree of permeability, and where karstic processes, proof by the presence of several exokarstic forms, have developed. In this way, the quarry of Andaroleta has the peculiarity of being exploited and located in an area which suffered, in past epochs, underground mining activity, concretely old iron oxides mines, so there exists a series of abandoned galleries through which underground water seeps and circulates, creating a complex underground circulation.

In order to carry out the follow-up of the water quality and to control the possible influence of flows from the exploitations, two sampling points in each quarry have been defined, far enough from each other to contrast the obtained results. The first point is placed in an area of the stream not affected by the works, and the second point is located in a place where the water come from the area affected by the quarry.

The analysed values are the content of solids in suspension and the content of hydrocarbons, because these are the two parameters that are commonly affected by the activity of quarries. An effective system has been developed for taking samples, which warrants that the final results from the analysis have optimum liability and representative value.

As prevention criterion, it is established Ley de Aguas 29/185 (Law for Water), on 2nd June, in its Annex to the title IV of Reglamento del Dominio Público Hidráulico (Regulation for Hydraulic Public Dominion), as reflected in Table 4.

	Limit values (mg/l)		
Parameter	Table I	Table 2	Table 3
Suspension solids	300	150	80
Hydrocarbons	40	25	20

Table 4.

The sampling was designed, at the beginning, with monthly periodicity. In the analytic results obtained during the first eight months of the project, the almost lack of appreciable quantities from the two parameters analysed was verified, (< 1 mg/l for Hydrocarbons and 10 mg/l average for solids in suspension). So, it was decided to make the sampling every two months.

Follow-up of the programmes of works carried out by exploiting companies in compliance with the Exploitation Project, Works Plan and Restoration Project

In the first step of compliance with this aim, several inspection points have been established from where the exploitation developments can be controlled; the observation of these inspection points have been complemented with the information

obtained from the blasting projects presented by the exploiters, in order to achieve an estimation of the production obtained in each blasting. This production is reflected in the detailed topographic drawings of quarries, comparing the data with those reflected in the Works Plan.

In the second step of compliance with these aims, it is required to obtain more liable production data than those achieved in the first step; for this, it is necessary to establish a detailed topography of the exploitations, since the topographic maps supplied by the exploiters dot not show the required details and the necessary currency, so the aim of this second step, in which we are nowadays working, is to carry out a detailed topographic surveying of the stopes and slopes where the works are supposed to be executed, not only for controlling the exploitation development, but also to carry out the restoration follow-up.

Measuring, control and minimization of atmospheric contamination

Atmospheric contamination originated by extractive industrial activity is basically produced by the existence of solid particles, gases and steams. Solid particles that settle by gravity action, denominated as sediment dust, are the main source of atmospheric contamination; gases and steams are produced during the detonation of explosives and by the emissions from equipments motors, but the intensity of this kind of contamination is irrelevant compared with dust.

Among the emission sources of atmospheric contamination the following ones can be found: lineal (circulation runways), mobile (transport vehicles), fugitive (raw materials stocks, dumps). It has also to be considered that in extractive activities an inevitable retreat of vegetal land is produced, with the corresponding surge of denuded surfaces, rapidly attacked by eolian erosion.

For identifying and quantifying contamination levels created by sediment dust, sediment dust collectors are used, which meet the norms specified in Ley (Law) 38/1.972 on 22nd December of Protección del Ambiente Atmosférico (Atmospheric Environment Protection). The analytic proceeding to determine the level of sediment particles inmision is recorded in the annex to this Law, and as a prevention criterion that established in the referred Law is used, which fixes the reference value of admissible situation of sediment particles in 300 mg/(m^2 day).

Vacuum pumps for dust collect are also employed in those cases in which only by using sediment dust collectors, the interpretation of the results is not satisfactory.

In order to evaluate the atmospheric contamination originated by sediment dust, it is taken into account, mainly the effects of exploitations on involved inhabited centres. Since the measured parameter is sediment dust drown by wind, several factors are considered, among which the following can be underlined:

- Wind direction and speed
- Air turbulence
- Ground humidity and temperature
- Year season and time
- Land topography: roughness and existence of excavation slopes
- Vegetation
- Situation of inhabited centres in relation to the quarries

The climatic factors referred are based on the data supplied by the Meteorology Basque Service of the Basque Government, in the meteorological station located in Iurreta and Urkiola for Mañaria municipal region, in the station of Güeñes for Güeñes municipal region, and in the station of Gernika for Rigoitia municipal region.

With the data obtained, the predominant directions of wind were determined and the measuring points established: these points have been installed, at the beginning, near to the villages, in order to evaluate the possible damages caused to them. The concrete location is based on the mentioned factors, taking also into account the lack of existence of obstacles that could make the function of wind screens, and the absence of dust sources which have nothing to do with the exploitations.

In the surroundings of each exploitation and concretely in the influence area for villages, a series of sediment dust collectors have been placed; the results monthly obtained in each measuring point are interpreted together with the climatological data and with the data of production activity in quarries, and they are compared with the limiting criterion adopted.

However, it is necessary to discriminate the contamination emission focuses, to adopt, if required, the adequate corrective measures; this discrimination has been troublesome in some exploitations, since as there exist quarries very near to the areas studied (only separated by the road C-6.211), quarries which exploit the same raw materials, it was not possible to discriminate them with the same sediment dust collectors net. This problem has been solved by using vacuum pumps collectors, installed in different points of each exploitation.

Measuring, control and minimization of acoustic contamination

The sound, as a contaminant element in the industrial extraction activity, is originated from two main sources: treatment of raw exploited materials and movible equipments. To identify the main sound sources, all the processes associated to the mining cycle are analyzed: hole perforation, blasting, loading, transport, treatment and raw materials storing, which may cause high acoustic levels.

To typify and quantify the sound levels, a digital sound device is used; is an integrated and portable sound device which measures the pressure sound, make the balance by the type A curve according to the norm UNE 20.493/92 and calculate the continuous equivalent sound level (Leq); it also register the peak instant values originated in a measurement.

Measurement proceedings

Different measurement points has been established to value the potential sound incidence on the villages. The main factor to select these points was the potential existence of inconveniences in the population; therefore the measurements have been made in the vecinity of the buildings nearer to the quarries, or where acoustic impacts may be higher. Also, it is selected to measure in the buildings exterior to minimize the inconveniences over the population and to reduce their awareness.

In reference to the measurement tecnichs and without specific sound laws in the Basque Country the recomendations of the norm ISO 1996 are followed. Therefore the measurements are made in the exterior of the buildings with the sound device placed at 1.5 metres high and separated a minimun of 3.5 metres from elements which can modify the signal. The microphone is placed at 1 metre from the operator and orientated directly to the sound source.

In each measurement point is gathered all climatic informations (temperature, humidity, wind directions), sound sources, predominant sources, activity level of each source and registered time.

We selected a temporary sampling due to the high number of sound sources and to their accidental nature; in this sampling the sound levels present during a determinated period of time is measured (Leq and the peak-fast value as the norm ISO 1996 recommends), repeating these measurements in a systematic and puntual way along the time.

Therefore is an stadistic study in which by following systematic and punctual measurements, the evolution of the sound level is analyzed, determining the most common value and his extreme values, approaching these in high proportion to the former, as much as high number of measurements are made.

The measurement of the Leq,60 (Leq during 1 minute) in each register point, is made every 5 minutes during a period of 20 minutes, so obtaining 5 measures; this action is repeated every 2 hours covering from 7.00 h to 22.00 h. With this procedure and through an strict measure of the Leq,60 and peak-fast values, and the predominant sound sources and their characterization, we can model the uncertain function we are looking for: sound in function of time.

However stadistic medium values are needed to allow a quick interpretation of the results, to compare the calculated value with the prevention criterion. Nowadays the most used criterion is NED or diurnal equivalent level (diurnal Leq media measure between 7.00 h to 22.00 h.)

Prevention criterion of damages

As a prevention criterion of damages and due to the fact that measures are made in the exterior of the buildings, we adopt the values proposed by the Public works and Urban development Ministry, in 1993 (Table 3)

It has been considered that the receptors are type II and NED values are applicated, so there´s no activity in the quarries between 22.00 to 7.00 h.

Two different graphics obtained in the measurement points, can be seen in the Figures 2 and 3.

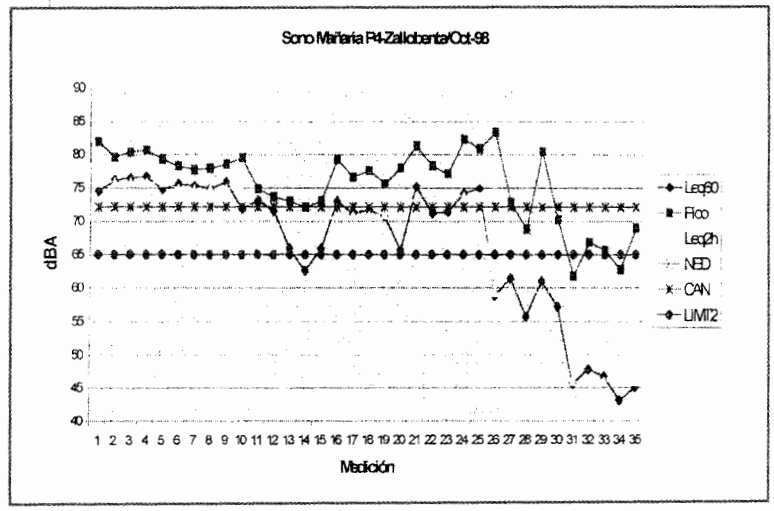

Figure 2.

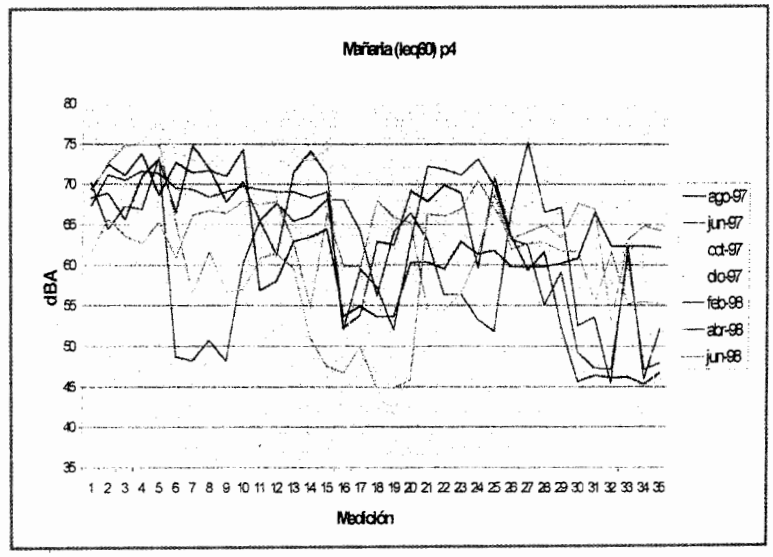

Figure 3.