Noise Map of the Port of Bilbao.

Design and Environmental Considerations

PR6993-IN-CM-102

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CONTENTS

1 INTRODUCTION

The main objective of the contract with the Port of Bilbao Authority, known as 'Technical assistance and provision of a sound level monitoring system in the Port of Bilbao" in accordance with the specifications of the second policy of the 4041 task and of the 4079 task of the HADA project report (LIFE 02 ENV/E/000274)', is to contribute to the economical development of the port infrastructures of Spain by defining evaluation tools that lead to progress in the working-out of the diagnosis and in the elaboration of the consequent action plan whose objective is to minimise acoustic contamination generated by Spanish ports both in the current and future scenario.

There are two steps in the development of this work:

Step 1. – Prototype system of evaluation and sound level control.
Step 2. – Sound level monitoring service.

Step 1 implies the design of the acoustic monitoring network of the Port of Bilbao, as well as the analysis of its application to other port surroundings. It also implies the definition of an evaluation methodology of the noise levels produced by ports activities, with its corresponding application to the Port of Bilbao, Noise Map, Analysis and Recommendations for improvement.

Step 2 consists of providing the necessary instrumentation for the introduction of a noise level monitoring network in the Port of Bilbao. This service also includes the network maintenance and the formation of the Port Authorities' staff for its proper use.

The results collected in this report correspond to the first step and concretely refer to the application of the Noise Level Evaluation Methodology in Port Environments (ref. PR6993-IN-CM-101).

2 OBJECTIVE OF THE STUDY

The objective of this project is to assess the acoustic impact on the surroundings of the Port of Bilbao by considering the different sources peculiar to the surrounding activities of the port.

The study will allow the sound level assessment of the housing development neighbouring the port. As well as the observation of the relation between the sound levels recorded in the monitoring equipment situated in the port and the estimated sound levels of the housing development façades.

3 ACOUSTIC NETWORK FOR PORTS. PORT OF BILBAO.

Applying the basic principles developed in the document "Methodology for the Implementation of a Noise follow up assessment and control system in Port Surroundings" (PR6993-IN-CM-101), an Acoustic Pilot Network was defined and started up in the Port of Bilbao.

3.1 Objective of the Monitoring System

Starting from the assumption that the Port of Bilbao has no '*dark points*' in which its daily activity implies noise-related inconvenience for the population (ratified by the lack of complaints), the choice of the components modelling the Monitoring System, its location and provision, were not approached as means to resolve a concrete and specific problem but were based on the fulfilment of the two following objectives:

Represent the sound level of the entire operations developed in the port zone, in order to characterise the acoustic environment of a determined area in any moment of the day or night. In accordance with the Noise Map, establish a control system that alert possible acoustic impacts on a residential zone when a certain sound limit has exceeded the measured levels associated with a concrete port activity.

These two objectives represent the most general impact that can be established by a

Monitoring System in a complex sphere where the noise sources are numerous as well as variable both in location and in intensity.

3.2 Equipment selection

In accordance with the objectives planned for the Pilot System, and also depending on the project budget, a Monitoring system formed by the following components was selected:

1. **Monitoring Terminal.** Model 3597 B&K Modular equipment, known as FIX EQUIPMENT, constituted by:

   - 4184 microphone
   - 4441 analyser
   - ZG 0146 power supply
   - UL 0212 controller
   - EtherPath SS1 network adaptor
   - Protective cover
   - Batteries and accessories

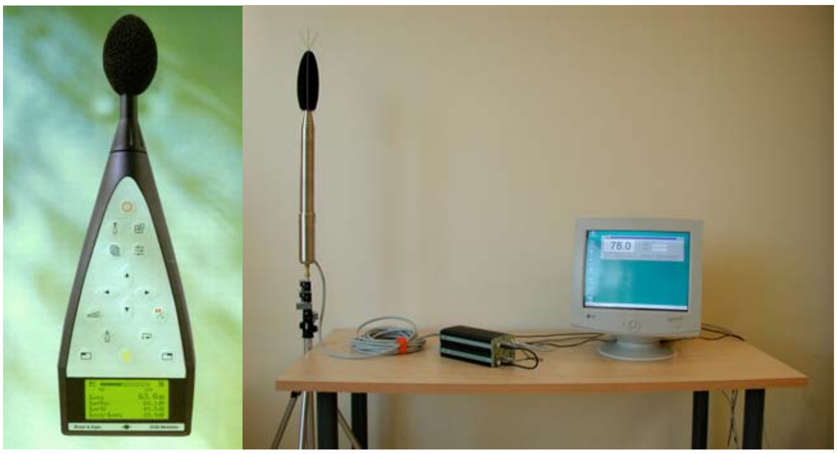


Figure #1: Components of a Monitoring Terminal

2. Monitoring Terminal. Model 3631 B&K portable equipment, known as MOBILE EQUIPMENT, constituted by:

- 4198 semi-permanent microphone
- 2238F sound level meter
- Protective cover
- Batteries and accessories

Figure #2: Components of a 3631 model

3. Control Station. The data processing, acquired and stored beforehand, is carried out by means of the B&K7802 noise data acquisition program for both terminals. The data transmission is also carried out through GSM technology for both units, with downloading in adaptable periods and without any information loss during the reception.

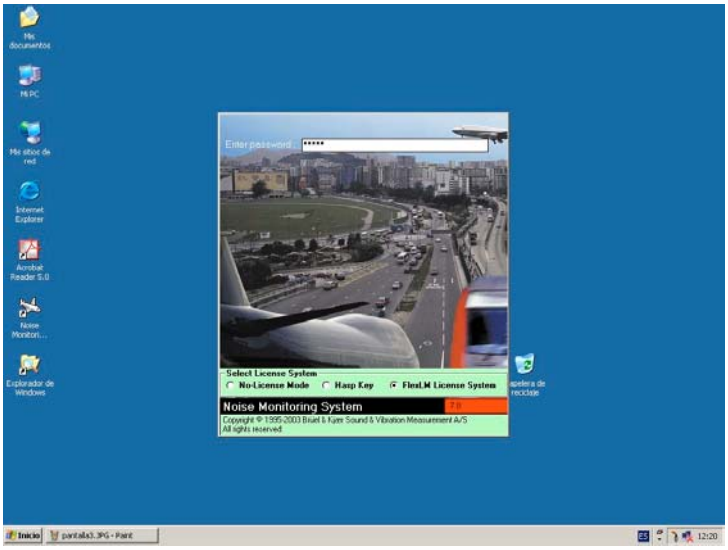


Figure #3: Monitoring terminal software control screen

The technical specifications of the two selected monitoring units (analysers) can be found in **Appendix 1**.

The motive for having two different Pilot System units is to properly value the most adapted technical complexity necessary to the particularities of a port environment, switching from the capacity and resistance of a modular equipment such as the B&K3597 to the mobility of a portable equipment such as the B&K3631.

As noticeable in the following pictures, there are differences in the installation of both equipments, which obviously has an effect on real possibilities of a position change. The main difficulty of the installation is related to the higher capacity of the unit for gathering and processing data.

Figure #4: Greater means, time and complexity are necessary for assembling the modular equipment (left)

3.3 Installing the System

Since the 22nd and 23rd of March 2004, the location of the two pilot monitoring system equipments are the ones shown on Figure 5. Letter A corresponds to the terrace of the ATM office building on wharf #1, and letter B to the superior part of the Bizkaia wharf V.6 pavilion (Bergé).

The control of the different activities that implies container movements, is expected to be carried out on wharf # 1 (letter A): loading and unloading, crane and truck movements, etc. The attempt to characterise a complex wharf, just as the Bizkaia wharf (letter B), is achieved through a variety of tasks resulting from the loading and unloading of different types of materials.

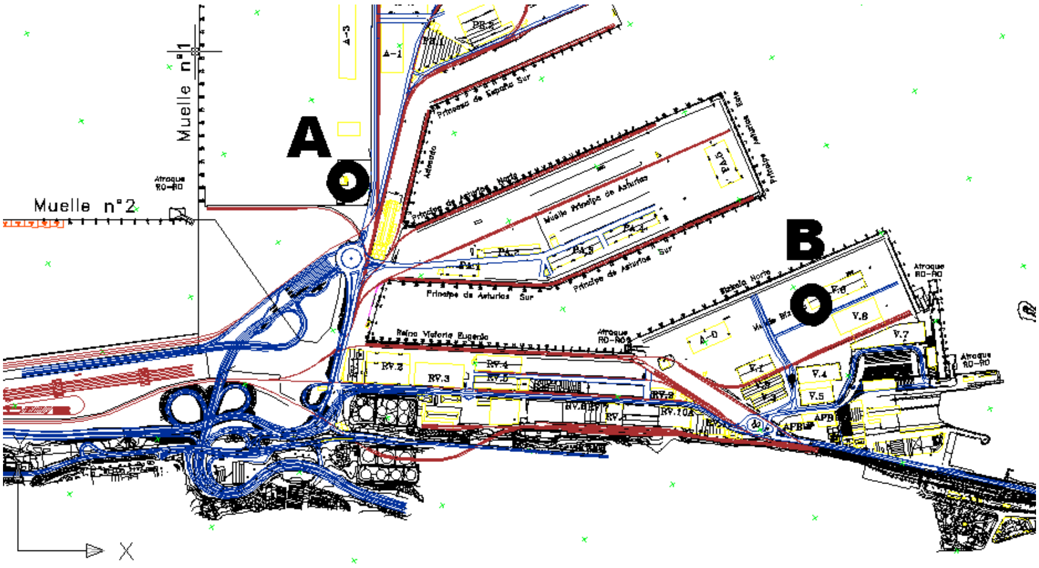


Figure #5: Locations of the monitoring equipments.

Once the primary objectives pursued by both equipments have been determined, the proper location of the terminals was established under the point of view of the general criteria referred to in the methodology document.

As for possible screenings, the two receivers (microphones) are directly in front of the zone that is meant to be characterised. A high position furthers the fulfilment of this point.

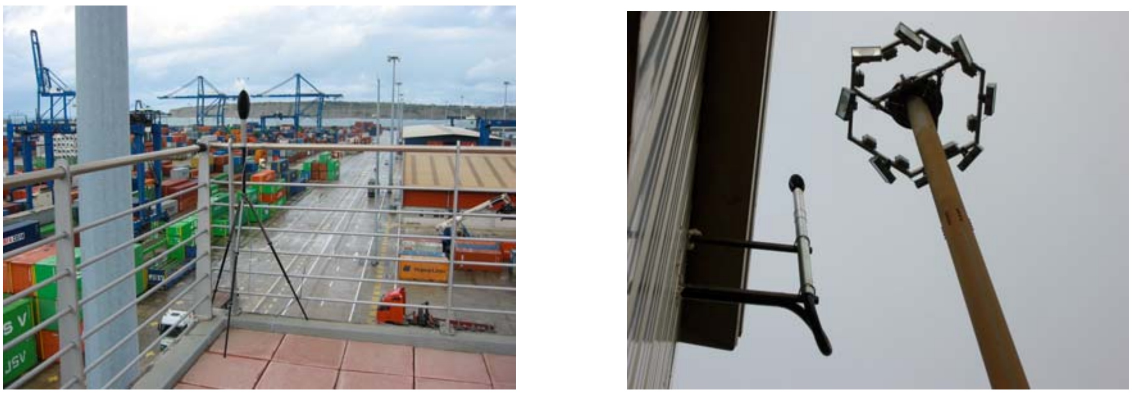


Figure #6: No screenings between the receivers and the noise source.

The positions were found by trying to avoid or minimise as much as possible the interference of extraneous sources to the ones that were meant to be characterised or controlled. In the case of the portable equipment (ATM terrace), the microphone is located on the opposite end of the Princesa de España wharf so that the loading and unloading noise influence of bulks and ferrous scrap be minimised. With hindsight, the influence of the activities carried out on the Princesa de España wharf was proved to be superior to what was expected; this aspect had to be considered in the evaluation of the sound levels collected by the terminal. In the case of the modular equipment (Bergé V.6 pavilion), the microphone was situated by the gable roof on the north side of the pavilion and was therefore protected from the effects of the RO-RO 3 (Toro and Betolaza) ramp activities.

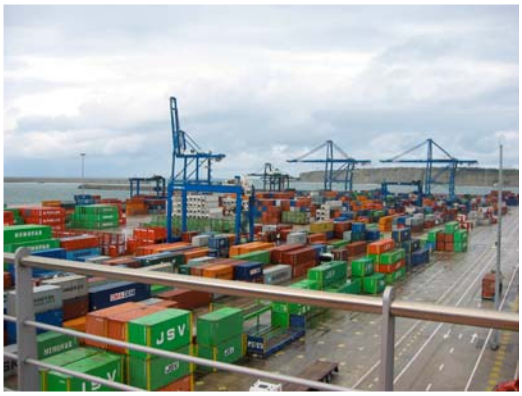



Figure #7: Positioning of the microphones facing the sources object of study

The effect of any *reflecting component* near the receivers must be avoided as much as possible; otherwise, this aspect has to be beard in mind when analysing the results. In this case, reflections were avoided for both equipments. The portable equipment was installed on the terrace of the building and the modular equipment receiver was situated on the slope of the pavilion.


Figure #8: Receiving equipment with direct reflection effects.

The two monitoring terminals are designed to function in bad weather conditions without registering any information loss. However, considering the type of activities carried out in a port environment, it is recommendable to protect them as much as possible, placing the body of the analyser on a high point or ensuring its proper protection.

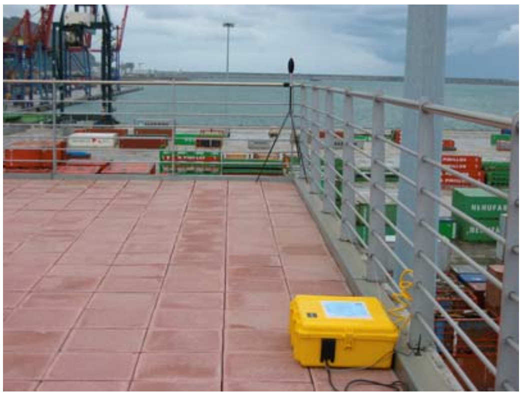



Figure #9: High-located equipment to ensure proper protection from contacts.

The Monitoring Systems in continuous mode need a reliable *electrical supply*. It is important to guarantee this aspect to avoid using the emergency batteries of the equipment; if not possible, the use must be shortened as much as possible.

Figure #10: Electrical connection of the portable equipment (left). Internal battery of the modular equipment (Right)

The mobility capacity of both equipments allows the modification of its location with relative convenience depending on new necessities or interests.

3.4 Configuration of the Monitoring System

As a basic configuration, both equipments record sound levels at intervals of approximately one hour. In both cases, an automatic connection for data unloading is carried out each 8 hours from its monitoring station. The Figure 11 shows a graph with the data downloading of one of the units.

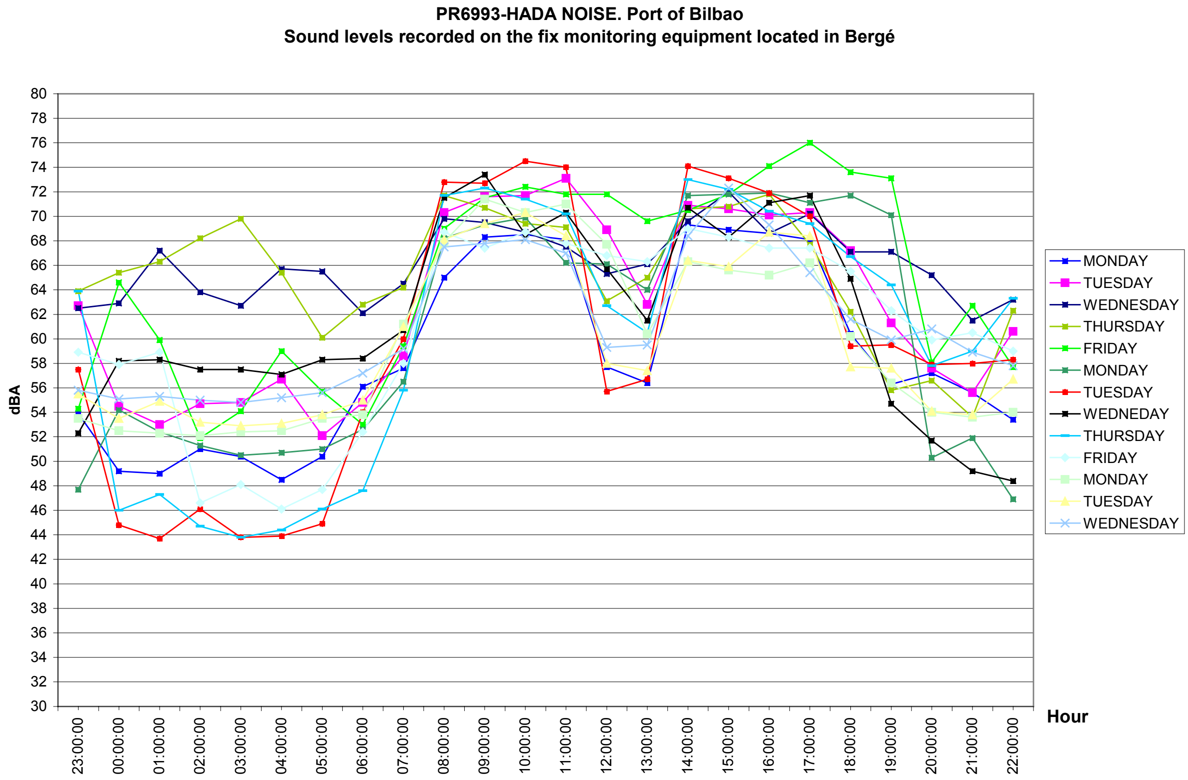


Figure #11: Sound levels recorded by the Equipment in Bergé

As a descriptor parameter of the sound situation, the continuous equivalent sound level of one hour with frequency A weighting ($L_{Aeq,1hour}$) was used. The first Monitoring System use is the simple observation of the sound level graphs, which allows analysing the working process evolution of a noise zone or source to be analysed. For example, the working schedule is noticeable on the graph with sound levels between 68-74 dBA between 7:30 and 11:30 and between 14:00 and 18:00. Between 11:30 and 14:00 (lunchtime), the levels decrease due to the port inactivity.

As a result of all this, the Port of Bilbao currently has the first port environment sound level Monitoring System of the State, and one of the firsts in Europe.

Ever since its installation and activation, the fix equipment has suffered several quite atypical breakdowns that have been rectified as they appeared. Since June 2004, the equipment only incidents occurred in periods of misconnection; in none of the cases did it result in a data loss once the connections had been restored.

The GSM equipment connection loss causes the blocking of the modem in charge of the information transmission. This blocking can be resolved by resetting the equipment.

This particular aspect will be followed up until the finalisation of the project, with the objective of assessing possible modifications of the signal transmitter so that connection losses can be avoided.

Figure #12: Mounting images of the FIX EQUIPMENT

Figure #13: Mounting images of the MOBILE EQUIPMENT

In order to optimise the use of monitoring equipment, a training activity (concerning the use of the acoustic software which gives access to the recorded data of the terminals) was held in November 2004. The different terminal configuration options were studied as well as the way to obtain the stored information.

The objective of the training formation was mainly to deal with the possibility, for the technicians of the Port Authorities of Bilbao, to modify, at the end of the project, the data reception (in the memory of the units) and transmission configuration (at the monitoring station) of both units by selecting the most appropriate one, depending on the case and on the pre-established objectives.

As expected, the follow-up and optimisation of the equipment performance will be maintained so that its entire and proper performance can be guaranteed in March 2005.

Finally, a complementary report about the MONITORING SYSTEM will be written with the current report so as to evaluate its effectiveness and give recommendations of improvement, change, etc.

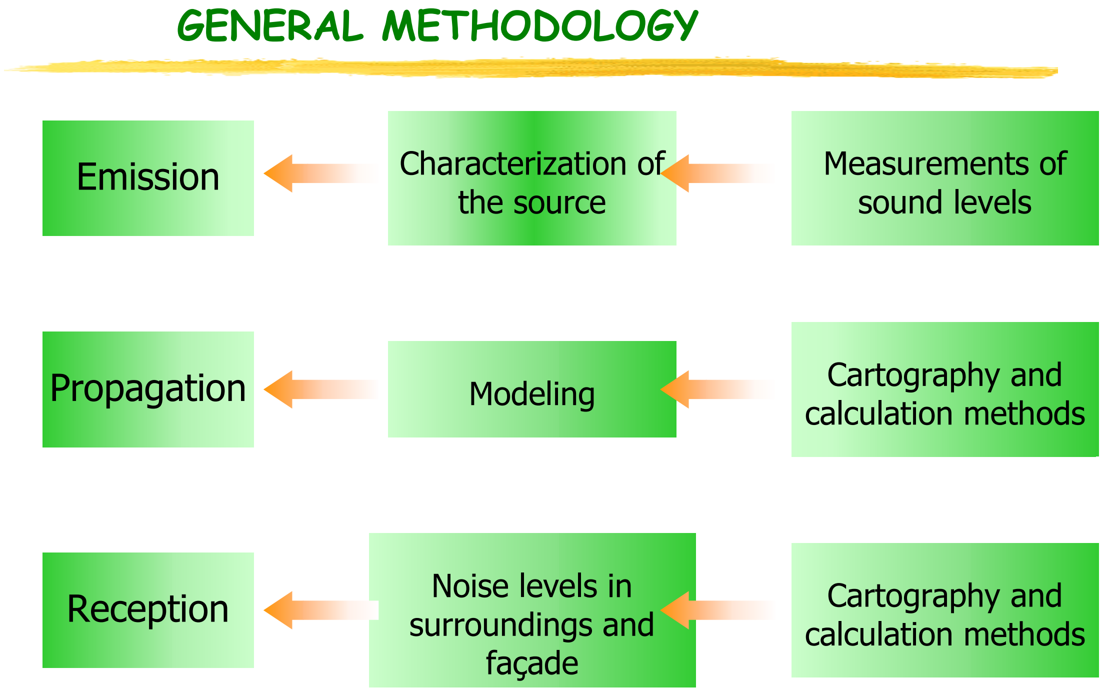
4 NOISE MAP. METHODOLOGY.

In order to carry out this study, the different steps that occur in the sound evolution were analysed separately: from its emission to its propagation and reception, especially in the places with higher noise sensibility, such as in housing development, health centres and learning centres.

The methodology used in this case combined noise level measurements with calculation method applications.

The measurements allow to establish the characterised noise source emission levels, whereas the sound propagation and noise levels perceived in the surroundings are calculated with the application of calculation methods.

The following box presents a general scheme of the applied methodology.



This methodology provides information about the contributions of the noisiest activities as well as a description of the sound impact of the port in the surroundings. Thus, when associating the noise levels with the sources which originates them, the study gives the basis to administrate the acoustic impact of the port. It is possible to subsequently estimate other working scenarios in which the source locations and the emissions can be modified or in which the efficiency of possible correcting actions to apply in the emission or in the sound propagation can be appreciated.

This approach matches up with the policy established in the European Directive about Assessment and Management of Environmental Noise (2002/49/EC) to tackle the environmental noise problem in the European Union with coherence and harmony. One of the major forces of this new Directive is its emphasis on the execution of noise maps and on the development of action plans, introducing a logical progression from the problem analysis to the development of correcting and preventive measures.

4.1 Characterisation of the Noise Source Emissions

The acoustic emission of noise sources represents its capacity to cause noise independently of its environment and is evaluated quantitatively with its acoustic power level, $L_{W,}$ in dB(A). The acoustic power is obtained from the sound pressure levels emitted in the surroundings.

In order to guarantee their validity, precise measurements, in which sound pressure levels were calculated in specific conditions of average time and space and sound field, were carried out during the measurement campaign. It was then possible to establish the noise source average and maximum power levels of the noisiest activities.

4.2 Sound Propagation

Once the noise source emissions considered L_W are established, sound propagation must be studied to understand the noise levels spread in the surroundings (reception and immission levels, Lp).

The study of external sound propagation was the object of numerous investigations in which different calculation methods quantifying diverse factor effects, that have an influence on the propagation, were created. In general, these effects were limited to the following attenuations:

Geometrical divergences (A_d): attenuation due to the distance between the source and the receiver.

Air absorption (A_a): energy loss caused by the particles present in the atmosphere.

Ground absorption (A_g): attenuation related to the kind of ground and to the height of the transmission path between the source and the receiver.

Reflections (A_r): contribution to the noise levels in reception of the transmission paths that suffered reflections on surfaces close to the source or receiver.

Barrier (A_b): Attenuation due to the effect of sound diffraction on obstacles found in the transmission path.

The generic formula that describes the sound immission level calculation could be the following:

$$L_p = L_W + A_d + A_a + A_g + A_r + A_b$$

That way, the noise level at reception, L_p, is obtained by applying the attenuations produced by each one of the considered effects on the emission level.

The European Directive about Assessment and Management of Environmental Noise defines provisional calculation methods for countries that do not have official methods, even though it recognises that none of the currently used methods satisfies the established requirements.

In the case of industrial sources, the method is the ISO 9613-2, 1996.
In the case of railway sources, the method is the Dutch norm SRMII.
In the case of traffic sources, the method is the French norm NMPB.

The application of the propagation calculation between sources and receivers in an urban environment is very complex and requires the use of acoustic calculation models. These models analyse the sound propagation paths, study factors to bear in mind in each case, and apply the defined formulas in calculation methods to obtain the sound pressure levels in the defined receivers in order to characterise the surroundings. The acoustic model IMMI 5.041 was used for this project.

The cartography supplied by the Authorities of the Port of Bilbao helped to define the cartographic model used by the acoustic software as a calculation base. The distribution of the construction components (buildings, pavilions), which can affect on sound propagation and on the location of the main noise sources, was in detail extracted from it. Complementarily, the surroundings cartographic information (municipality of Santurtzi) was obtained from the Basque Government's plan of the zone of interest at a 1:10000 scale, in which 3D data are available.

4.3 Assessment Criteria

There is currently no legislation that regulates external sound levels caused by activities with the characteristics of the Port of Bilbao be that in the Country or in the Basque Autonomous Community. In this situation, municipal regulations are resorted to so as to assign sound limits and to assess possible situation of acoustic impact.

In the Urban Development General Plan of Santurtzi (BOB #116. 22nd of June 1998), it is indicated that with the exception of the traffic, no type of noise exceeding the equivalent continuous noise levels to those shown in the following table will be permitted:

USE	LAeq 8-22 h (dBA)	LA eq 22-8 h (dBA)
Sanitary	45	35
Residential	55	45
Industrial	70	60
Other uses	65	55

The assessment of the sound levels caused by the Port of Bilbao in the municipality of Santurce will be carried through from these limits.

4.4 Assessment of the Acoustic Situation

4.4.1 NOISE MAPS

The noise map objective is to describe the acoustic impact caused by the port activity outside its environment.

The acoustic modelling of the Port of Bilbao surroundings requires the definition of the receiving points in which sound levels can be evaluated. In order to carry out the Noise Map of the external surroundings, receivers that cover the whole study area were installed each 10 metres.

The chosen height, for the realisation of the study, was 4 metres. That way, the study is in accordance with the European Directive END and represents the levels to which the local buildings are exposed. The levels perceived by the pedestrians are on the environmental security side, since they could be lightly inferior to the calculation of 4 m.

The acoustic model therefore obtains the noise levels that characterise the assessment periods considered in each one of these reception points. 5dB range isophonic lines are created from external noise levels, corresponding to the noise levels of the whole sources considered in the different assessment periods.

4.4.2 LEVELS ON FAÇADE

Various points located on façades of different housing nearby the port were selected in order to value, by means of the recorded noise levels, the impact on all the buildings of the surroundings.

These points are situated outside the building, at different heights. The levels obtained show the incidental noise or, in other words, the noise perceived without taking account of the reflection on the building. The results are similar to the ones obtained in an environmental noise measurement in accordance with the ISO 1996 norm.

In each receiving site, the different source contribution data were analysed so as to establish the sound level relation between sources and receivers obtained from the propagation conditions laid down by the study.

Finally, the existing relation between the housing façade-located noise level receivers and the noise levels obtained for the two monitoring unit positions was studied. The analysis of this relation will allow determining the order of the level that cannot be exceeded in the monitoring stations, thus ensuring that the housing development suffers no acoustic impact.

5 NOISE MAP OF THE PORT OF BILBAO

5.1 Source inventory

The noise sources that can be identified within the context of a port activity were grouped together in accordance with three priority levels.

On Figure #14, the classified zones are organised in priority level (red), considerable level (yellow) and negligible level (green).

The priority level includes:
Nº 1 (ATM) and nº 2 (TMB) wharves, Nemar wharf, Adosado wharf, Princesa de España wharf and the Free-Port warehouse.

The considerable level includes:
Bizkaia wharf, Reina Victoria Eugenia wharf and the RENFE's loading terminal.

The negligible level includes:

Príncipe de Asturias Norte wharf, *Pride of Bilbao* ferry wharf and the TERMICAR.

Both the automotive roads and the train railways were considered in one or another group, depending on the IMD and the resultant train movements.

Figure #14: Identification of noise sources in the Port of Bilbao. Classified by priority.

The regular port working schedules are from 8:30 to 12:00 and from 14:00 to 18:00. There is usually no activity during the night schedule, apart from the container movement ATM and TMB docks that sporadically have evening and night activity.

As a result of the inventory, the noise sources that were considered for their characterisation are the following ones:

Nemar, Princesa de España and Adosado wharves.

The main activity is due to the movement of ferrous scrap, pig iron and briquette.

These are the noisiest sources. The operations that take place in this area are the bridge crane-assisted unloading from boats to wharf and the truck loading with crane or excavator.

ATM, TMB wharves and R.E.N.F.E. Container Terminal.

The main activity is due to general merchandise movement by means of bridge cranes and reachstakers. The movements occur from boat to truck, from truck to dock, and at last, in the loading and unloading of merchandise trains.

North Bizkaia and Príncipe de Asturias wharves.

The activity is due to general merchandise movement. This merchandise does not produce a significant noise level when loaded or unloaded. The main noise source rather occurs during its manipulation on the wharf with the fenwicks, when moving merchandise from the wharf to the warehouse (and vice-versa) as well as during the merchandise truck and train loading and unloading.

Toro and Betolaza dock.

The activity on this dock is due, on one hand, to paper reel transportation with trucks from the boat to the warehouse. It was verified 'in situ' that the noise caused by this activity is very low compared with the rest, reason why its characterisation was not considered necessary.

On the other hand, the activity is the result of the train loading with paper reels by means of fenwick cranes or reachstakers. Some reachstakers move out the reels from the warehouse and place them on mobile platforms. The others transport them from these platforms to the trains. The sound levels generated during the process are significant but are reflected off by the warehouse buildings and by the train.

R.E.N.F.E. container and classification station.

In the classification station, the only existing activity is the railroad traffic. There are no container movements.

The container station is where the loading and unloading of containers transported by train take place. The main sources are therefore the container movements by means of cranes and the truck traffic.

In all the enclosure of the port.

Truck and train movement: internal traffic and port area access roads.

5.2 Acoustic characterisation of sources

During the months of March to June 2004, the corresponding acoustic measurements around the considered sources were achieved. These measurements consisted of recording the operative cycle sound levels of each noise source on 1/3 octave bands. The measurements were taken close enough to the noise source so that external influences could be avoided. The sound power of each one of the considered sources were calculated from these measurements.

5.2.1 SCRAP MOVEMENT

In order to establish the methodology to characterise the noise caused by ferrous scrap movements, the processes involved in the operation were studied as well as the noise level variation in time for each one of them.

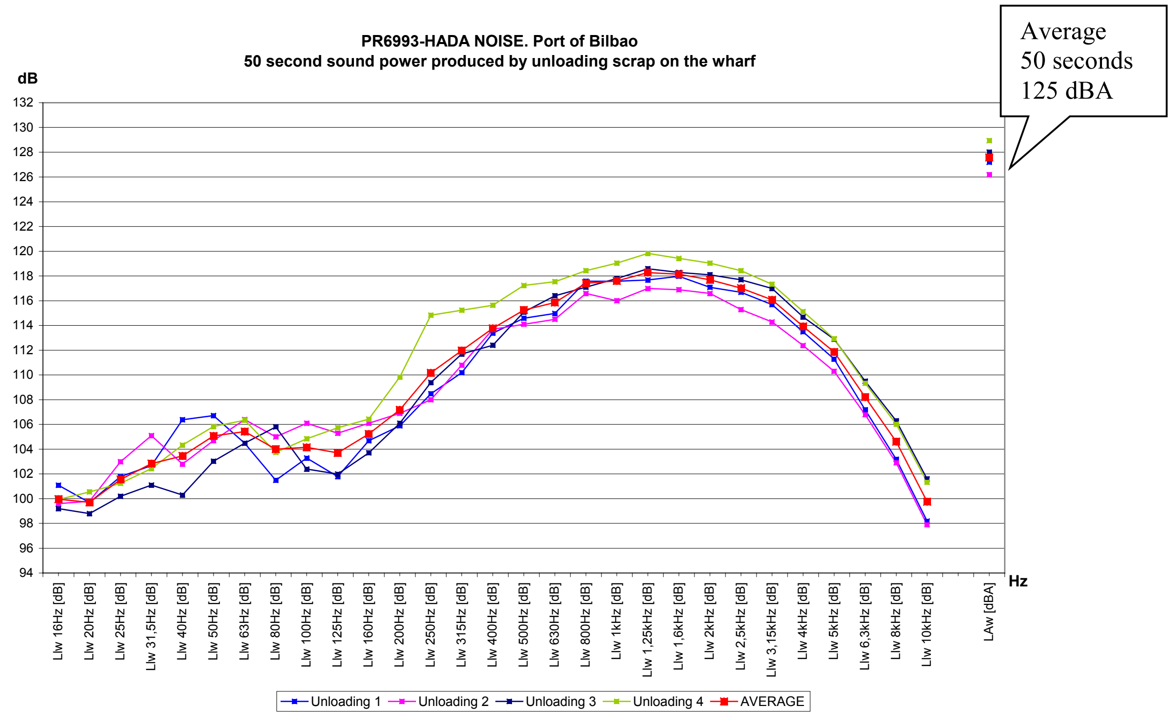
The scrap unloading on the wharf and the scrap loading on trucks were also studied independently.

- *Unloading scrap on wharf*

The scrap unloading on wharf is carried out by means of bridge cranes. The noise is produced when the load is dropped on the wharf.

By means of the controlled measurements when the load is dropped on the wharf, the sound power level of each one of these operations was characterised. The process in which the crane hoists the load from the boat, unloads it on the pile of scrap and goes back to pick up more material lasts approximately 50 seconds.

In the following graph, the results of the sound power on spectrum levels of 1/3 octave are resumed. The red line shows the average energetic spectrum of the whole measures.



In the following table, the value of the average power associated with a 50-second scrap unloading on the wharf is shown in bands per octave:

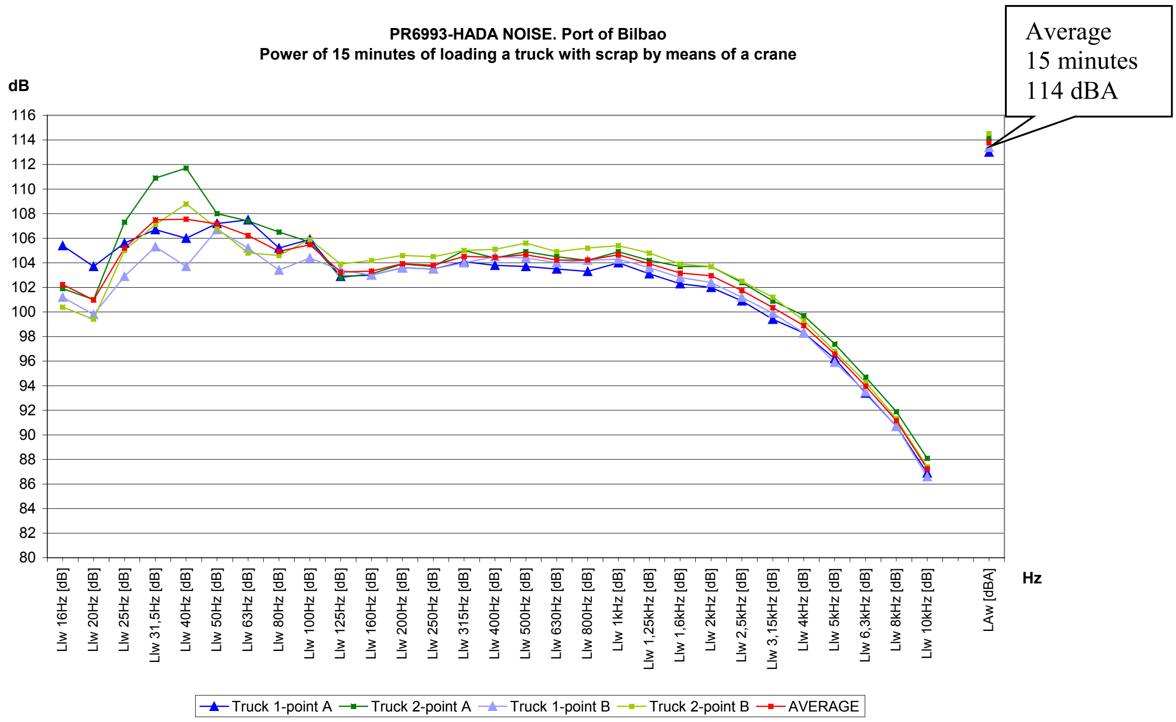
	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Llw [dB]	105	107	107	113	118	120	120	117	108	125

- *Scrap loading on trucks*

Cranes usually carry out the loading of the scrap. During the measuring campaign, the loading of two scrap trucks from two different measurement points was calculated. It takes approximately 15 minutes to load each truck.

Figure # 15: Loading trucks with scrap by means of a crane.

In the next graph, the power related to the 15 minutes necessary to load the first truck from two different measurements points (point A and B) is shown in blue. The green line represents the loading of the second truck from these same two locations. The red line represents the average value.



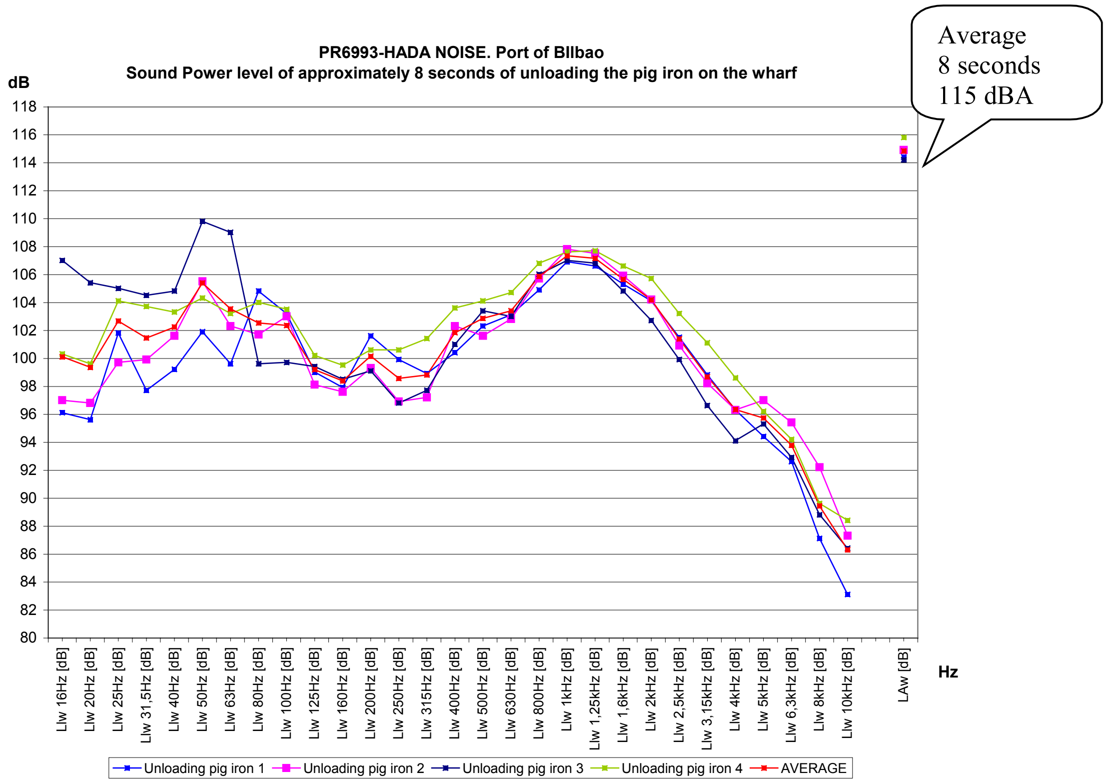
The spectrum is very regular in the middle frequencies, decreasing between 1.6 KHz and 10 KHz. In the following table, the average power related to the 15 minutes necessary to load a truck with scrap is shown in bands per octave.

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Llw [dB]	112	111	109	109	109	109	107	104	96	114

5.2.2 PIG IRON MOVEMENT

- *Pig iron unloading on wharf*

Pig iron unloading from boat to wharf is carried out with bridge cranes. During the source characterisation, two cranes simultaneously unloaded the freight. Due to this circumstance, it was not possible to characterise a complete cycle of the unloading operation. The time corresponding to the release of the material (about 8 seconds) has therefore been taken as the characteristic time of the measurement.



There is a certain disparity in the low frequency levels, especially in the Unloading Pig Iron 3 measurement. However, the response in high frequencies is similar for all the measurements. The spectrum shows that the maximum sound levels are concentrated in 1 KHz and 1.25 KHz.

In the following table, the average power related to the 8 seconds in which the pig iron is released on the wharf is shown in bands per octave.

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Llw [dB]	107	109	105	104	108	112	109	102	96	115

- *Pig iron loading on truck*

The pig iron loading is carried out with an excavator. Only three shovelfuls of pig iron are loaded in each truck because of the weight of it.

In the following images, the sound levels recorded for the loading of each truck is shown. The three moments in which the pig iron is dropped in the truck can clearly be distinguished on the recording. The two first times, it falls in an empty truck and produces a sound level considerably superior to the last one, in which cases it falls on a pile of pig iron. The highest sound levels of the Port of Bilbao are caused by this activity.

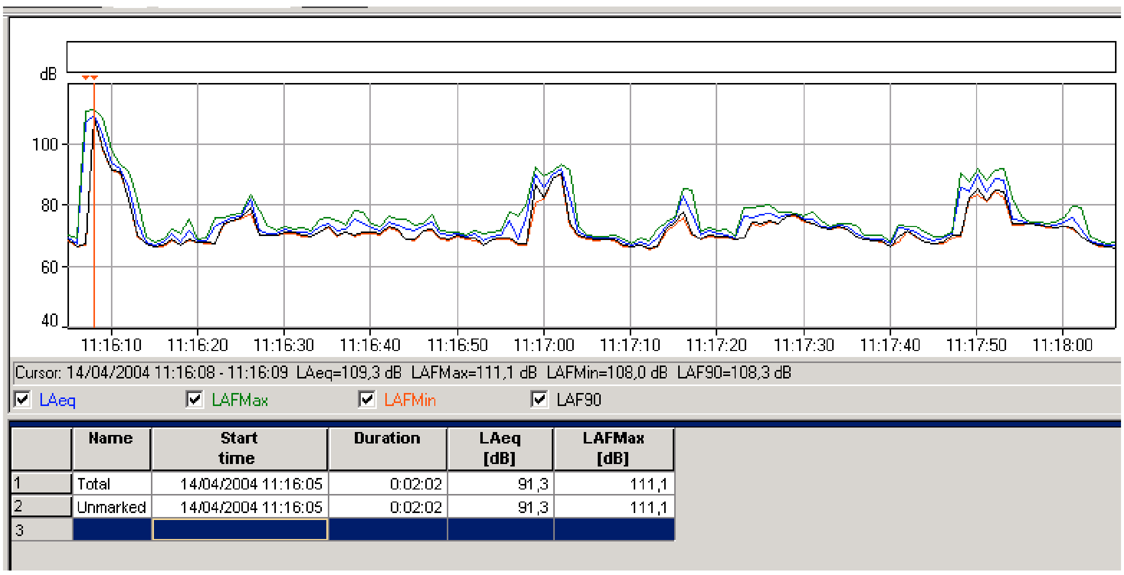
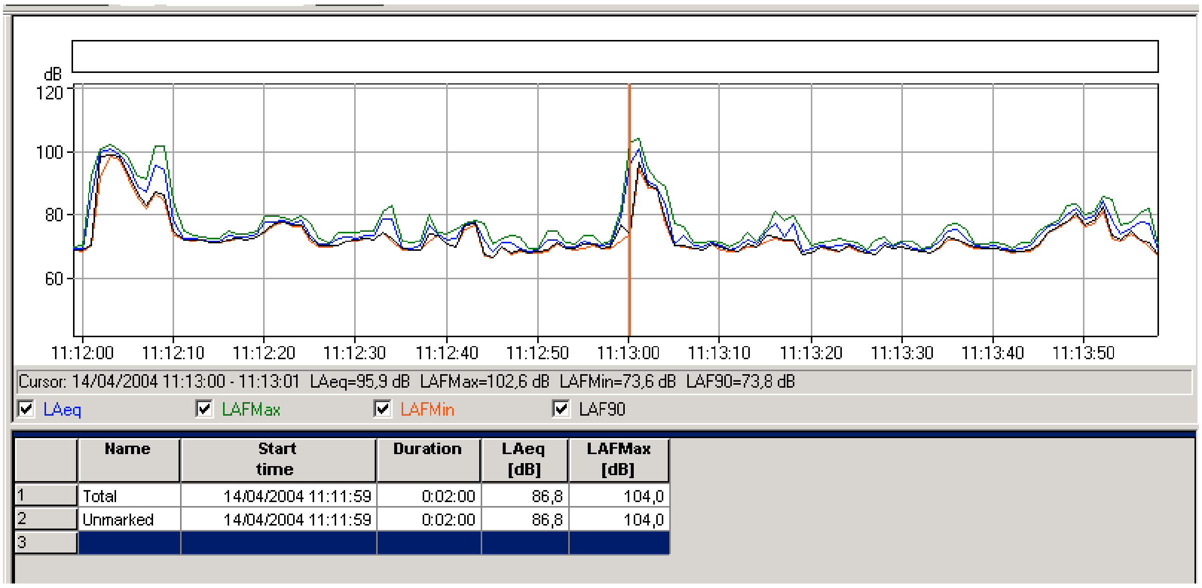


Figure #16: Sound levels of the loading of a truck with pig iron.

Just as shown in Figure #16, for the first unloading (time 11:16:05), the maximum sound level recorded at a distance of 31 metres is 111dBA; for the second unloading (time 11:17:00), the maximum level is 93,3 dBA; and for the last one (time 11:17:50), the maximum level is 91,5 dBA.



	Name	Start time	Duration	LAeq [dB]	LAFMax [dB]
1	Total	14/04/2004 11:11:59	0:02:00	86,8	104,0
2	Unmarked	14/04/2004 11:11:59	0:02:00	86,8	104,0
3					

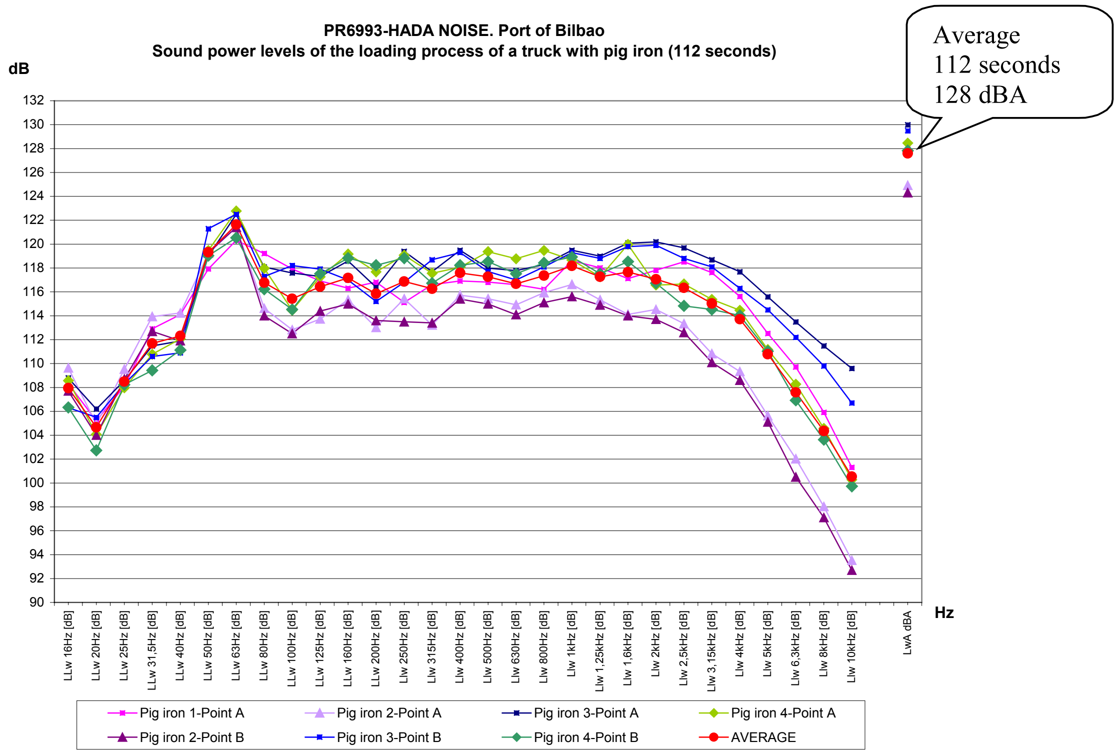
Figure #17: sound levels of a truck loading with pig iron.

In the Figure #17 example, for the first unloading (time 11:12:05), the maximum sound level recorded at a distance of 31 metres is 101,7 dBA; for the second unloading (time 11:13:00), the maximum level is 104 dBA; and for the last one (time 11:13:53), the maximum level is 85,4 dBA.

When analysing the sound levels produced in the different truck loadings, we come to the conclusion that the height from where the load is dropped and the velocity of this action have an influence on the noise levels.

On average, the loading of each truck lasts 112 seconds. This includes the three times the pig iron is dropped plus the noise caused by the excavator when picking up the material. In the following graph, the sound power of the whole process is shown.

The peak at 63 Hz is mainly due to the noise of the excavator handling pig iron.



The spectrum in bands per octave of the sound power of the loading process of a truck with pig iron (112 seconds) is the following:

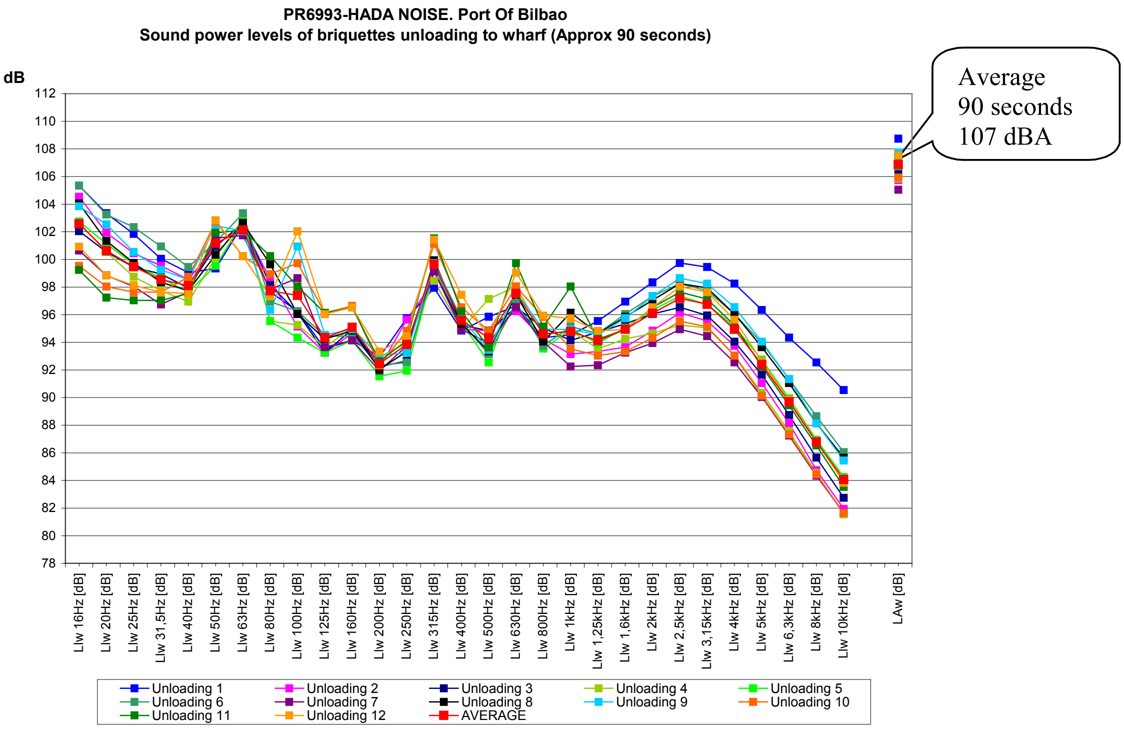
	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Llw [dB]	116	124	121	121	122	122	122	118	110	128

5.2.3 BRIQUETTE MOVEMENT

During the measurement campaign, the briquette unloading from boat to wharf (Príncipe de Asturias Norte wharf) was characterised.

The movement is carried out with bridge cranes. The complete characterised cycle starts at the moment when the material is picked up form the boat and put down on the wharf and finishes when the crane goes back to the boat to pick up a new load of material. The length of this cycle is approximately 90 seconds.

The unloading sound power of a whole cycle is shown both on a graph and on a table as follows:



The average power associated with a complete cycle of briquettes unloading to wharf (90 seconds) in bands per octave is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Llw [dB]	104	105	101	101	101	99	101	100	92	107

5.2.4 FREE-PORT WAREHOUSE

Merchandise storage activities and further truck loading for transportation are carried out in the Free-Port warehouse. The activity is achieved in a close enclosure, apart from the doors that remain open during the whole process. Since there are several handled materials, the noisiest detected emission, which is the pig iron transfers to the warehouse, was the one characterised.

The emission data obtained from the characterisation of the external pig iron manipulating process emission was taken and, through the application of the acoustic impact of the forecast software used for achieving the Noise Maps, a Free-Port warehouse dimension building was generated, enveloping the precise sound source equivalent to the activity, so that the enclosure roof and walls acted as new emitters.

5.2.5 TRAIN LOADING WITH FENWICK IN TORO Y BETOLAZA

The Toro y Betolaza dock carries out a paper transportation activity. The paper reels are transported from the wharf-located boat to the Toro y Betolaza warehouses with trucks that load up the merchandise directly form the boat hold. This activity generates noise levels classified in the ‘negligible’ category due to its weak repercussion on the surroundings.

The paper is transported from the port to its final destination, the train. The train is loaded in front of the Toro y Betolaza warehouses before leaving the port to go to the RENFE terminal.

The dock has two warehouses of material and the train loading is achieved in front of one of them. When the train is loaded in front of the first warehouse, closer to the wharf, the noise generated by this activity is reflected towards the exterior since it is produced between two buildings and covered by a Uralita roof. On the Figure #18 photo, the train loading area in front of the first warehouse is shown.

Figure #18: train loading area in front of the first Toro y Betolaza warehouse.

The activity zone in front of the second warehouse is also fairly reflected towards the exterior since the activity is produced between the warehouse and the train. However, a certain air propagation of the noise is allowed for it is not covered.

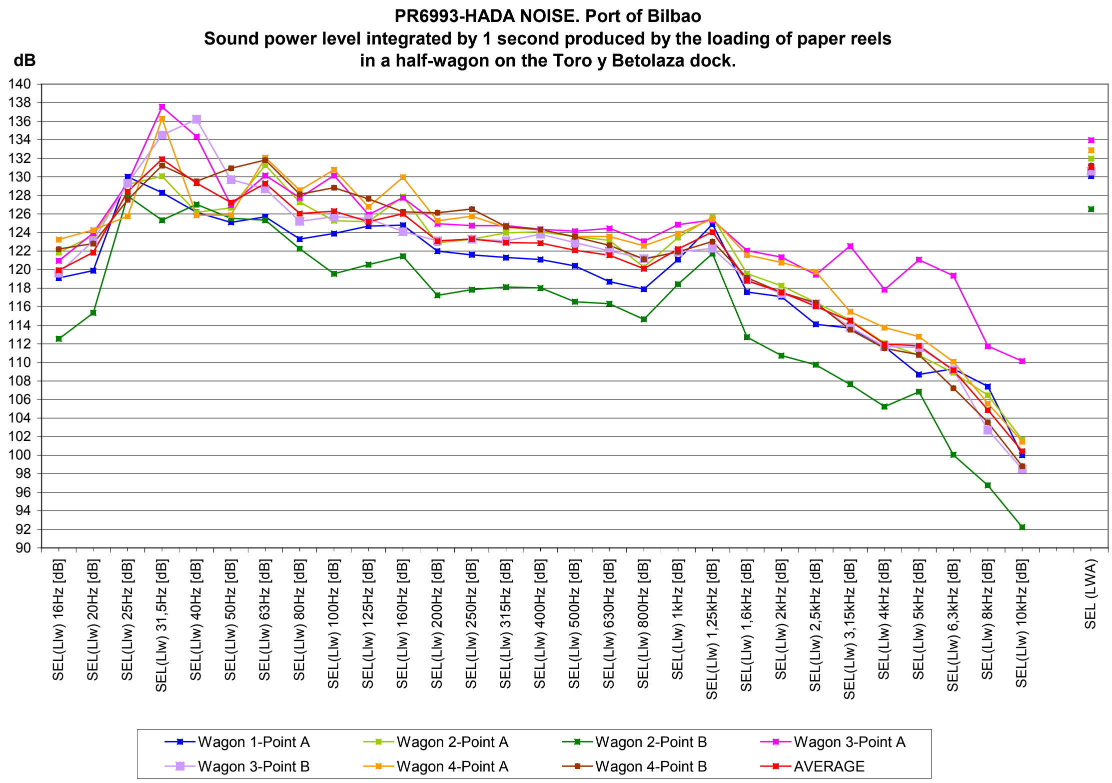
A train with ten double-wagons was characterised. Each wagon has two doors; the train is loaded half a wagon at a time from end to end. The loading process consists of opening the first wagon door, putting in the load and closing the door. Once closed, the second door of the wagon is opened for the loading until the 20 half-wagons are completed. Each half-wagon has the capacity for five paper reels of 1900 kg, which are the ones used for taking the measurements.

The paper reels are loaded on the train directly from the warehouse with a fenwick (see figure #19); or the reels are taken out of the warehouse with a fenwick, put on a platform outside, while another fenwick picks up the reels and puts them in the train (see figure #20).

Figure #19: train loading with fenwick

Figure #20: train loading with platform

The loading process of each half-wagon has a very variable duration. It can take between 2:30 minutes and 6 minutes. Because of this variation, the calculated power was integrated by 1 second so that the activity time variation did not affect the results. The loading power of a half-wagon integrated by 1 second (SEL, Lw) is shown in the next graph.



Since the activity occurs in one area, the sound power calculated is distributed along the whole area in which the activity is produced. That way, the area emission has to produce a sound level calculation identical to the sound levels measured in the measurement points.

During the measure campaign, sound pressure levels were brought to completion in 4 points within the area. The measurement points were named Receiver TB1, Receiver TB2, Receiver TB3 and Receiver TB4. They are located as shown on figure #21. The orange area represents the train loading activity zone and, therefore, the noise source of the area.

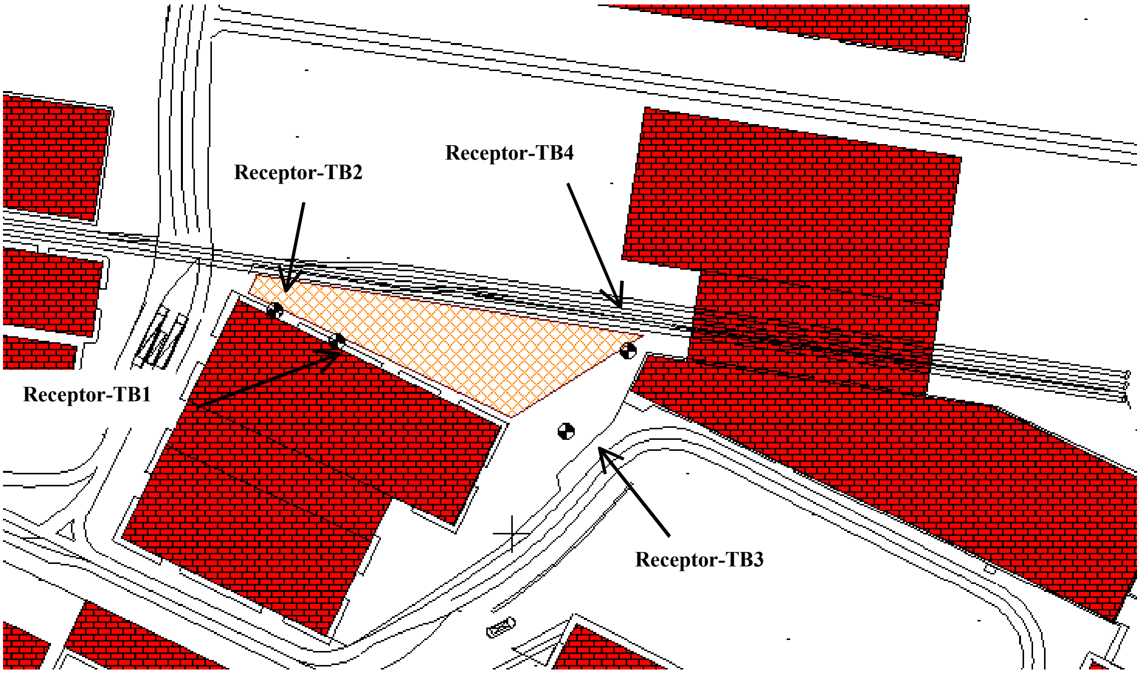


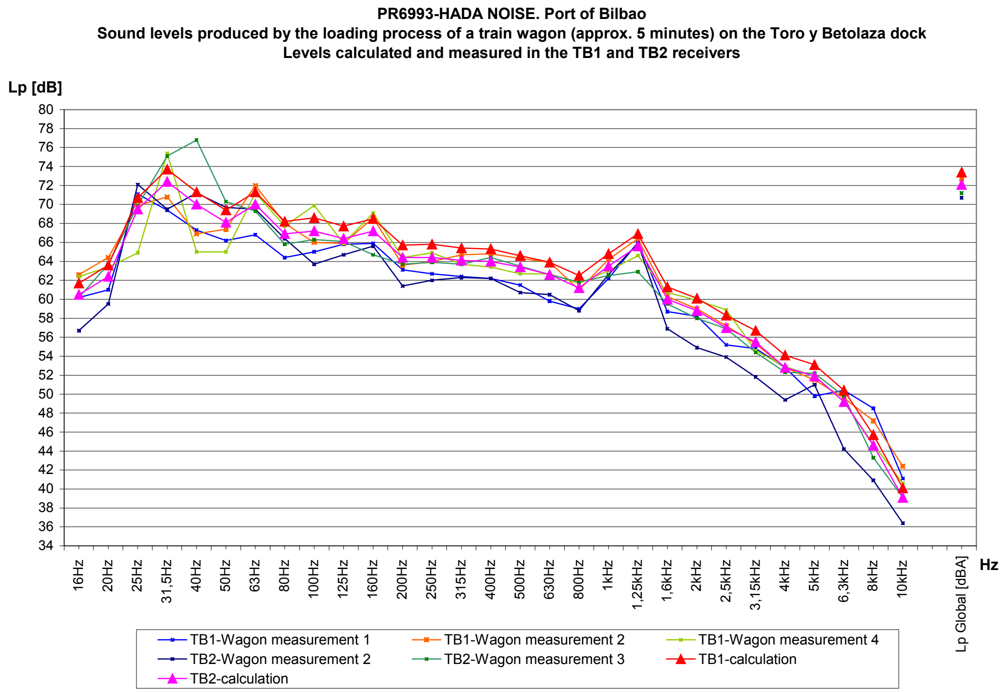
Figure #21: location of theToro y Betolaza dock measurement points

The power level attributed to the loading of a wagon, of an approximate duration of 4 minutes, was used for the adjustment process as follows:

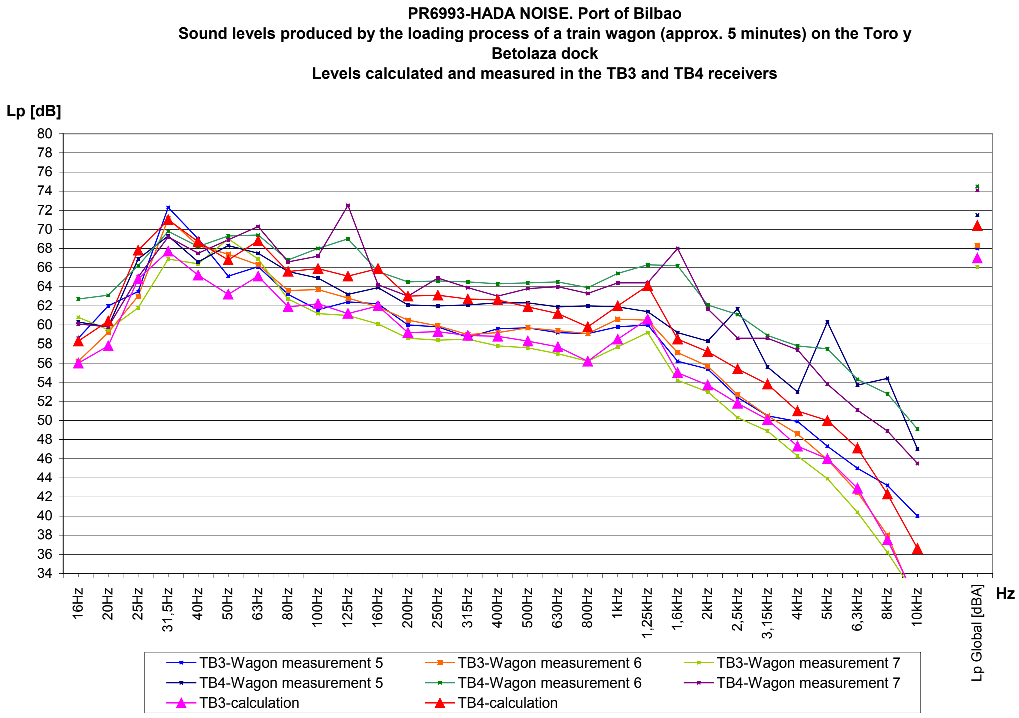
	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW´´ [dBA/m^2]
LIw´´ [dB/m^2]	76	74	72	69	68	69	64	59	53	72

Assigning this power to the area shown on figure #21, the sound level calculations are carried out to the points where the measurements were taken. The following comparative graphs were obtained by comparing the results recorded with the measurements and the results calculated with the model after the adjustment of the area source emission. In the first one, the levels of the TB1 and TB2 receivers are compared. In the second graph, the results of the TB3 and TB4 receivers are compared.

Comparison of the sound levels measured and calculated in the TB1 and TB2 receivers:



Comparison of the sound levels measured and calculated in the TB3 and TB4 receivers:



The adjustment between the levels calculated and measured in the TB1 and TB2 receivers is correct since the difference is approximately 1 dB. The TB3 receiver adjustment has a 1-dB deviation; the power assigned to the area therefore reproduces the measured sound levels. The TB4 receiver shows the greatest difference between the sound levels calculated and measured. The difference reaches up 4 dB. This difference is due to the presence of another source, which is the truck road nearby the measurement point. The power attributed to the area only represents the train loading source. The passing of trucks is not taken into account since it is not considered part of the activity to characterise.

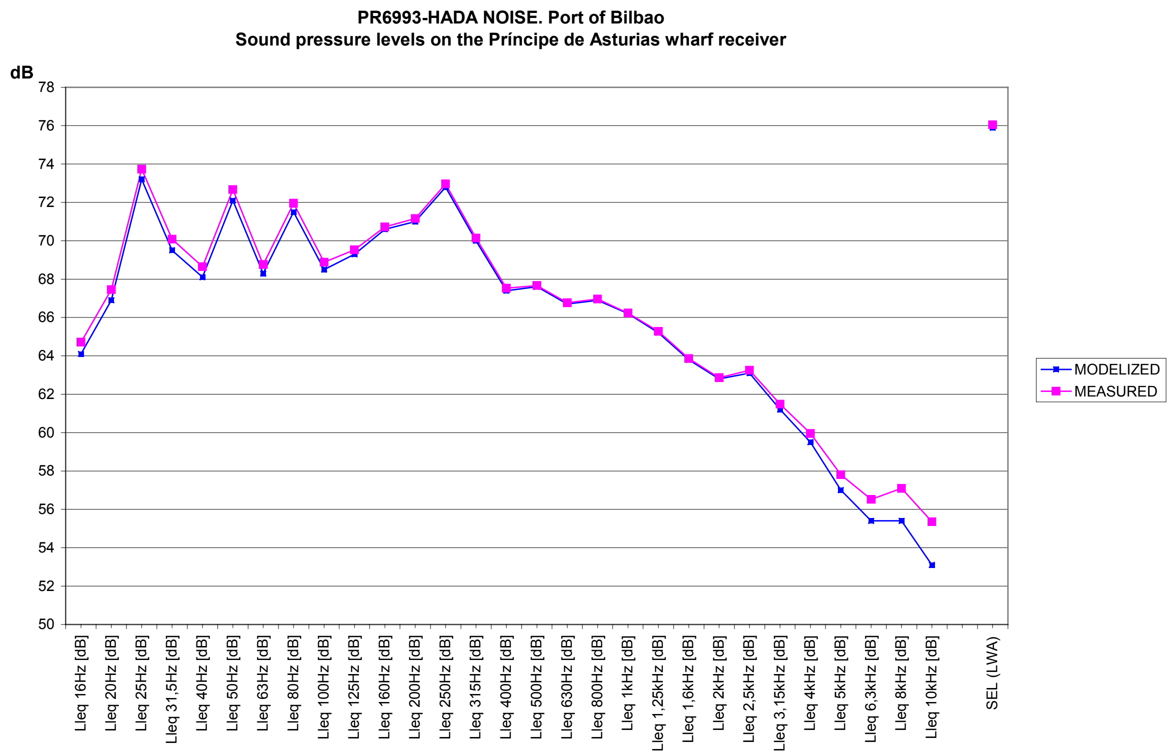
After validating the power assigned to the loading of a wagon (power of 5 minutes), the area power integrated by 1 second (SEL) from which the calculation of a whole day is carried out, as shown in the following table:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	SEL (LAW´´) [dBA/m^2]
SEL (Llw´´) [dB/m^2]	61	71	80	84	89	92	89	84	75	96

5.2.6 PRINCIPE DE ASTURIAS WHARF. GENERAL MERCHANDISE.

The Príncipe de Asturias wharf has a general merchandise movement. The loading and unloading of this merchandise does not usually cause very high sound levels. The main sources are the lifting cranes, mainly the security whistle that they emit when moving, and the truck traffic.

Long-length measurements were carried out to characterise this source so that the measured equivalent level would be an average of all the present activities. The power is distributed in the whole area where the activity takes place. Just as described in the Toro y Betolaza emission characterisation, the emission adjusts to the measurements taken. In the next graph, both the sound levels measured in a receiver and the ones obtained from a calculation model are shown, taking in consideration the sound power per square meter shown in the following table.



Power per square meter at the Príncipe de Asturias wharf:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW” [dBA/m^2]
Llw” [dB/m^2]	74	74	72	74	70	69	66	63	59	74

5.2.7 ATM AND TMB DOCKS

Container movement activities consisting of three different operations take place on these docks:

- The first operation is the unloading of containers from boat to truck and vice-versa. These operations are carried out by means of a portainer crane.
- The second operation is the movement of containers on the docks. These movements are executed with transtainer cranes if the containers are full, and with the reachstaker cranes if they are empty. There are delimited zones for each type of container, and therefore

working areas for each one of these machines.

- As a third operation, the trainloads meet with containers in a different area than the ones inside the dock. This operation is also achieved with transtainer cranes.

- *Container movement with Portainer*

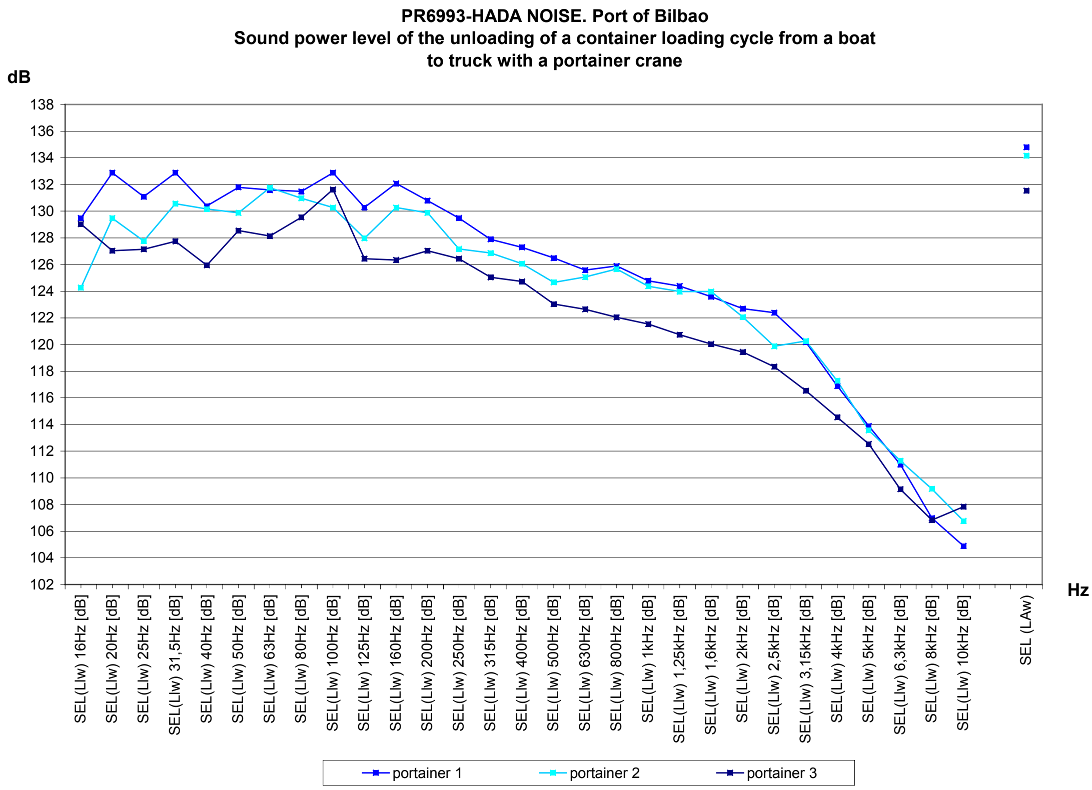
As commented before, there are 2 types of movements: the loading and the unloading. The process is quite similar in both cases.

When unloading a boat, the trucks, in line and with their engine ticking over, go one after another underneath the portainer crane so that it comes down, takes up the container from the truck, hoists it and places it on the boat. The loading process is the opposite: the crane picks up the container from the boat, hoists it until it gets at the truck height and then puts it down on the truck. The main noise sources in both cases are the metal contact when picking up and putting down the container as well as the engine of the crane. The portainer moves along the boat to place the containers. In these transfer movements, the crane emits a security whistle.

Since the length for loading a container can change a lot, the power level has been integrated by 1 second. The power levels, both in graph and bands per octave table, are shown next.

Figure #22: Portainer hoisting a container

The next graph shows the power spectrum (in dB) in 1/3 octave band of the loading of a container integrated by 1 second:



The average power of the values are shown in the following table:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
SEL(Lw) [dB]	134	135	135	133	130	129	126	122	113,3	141

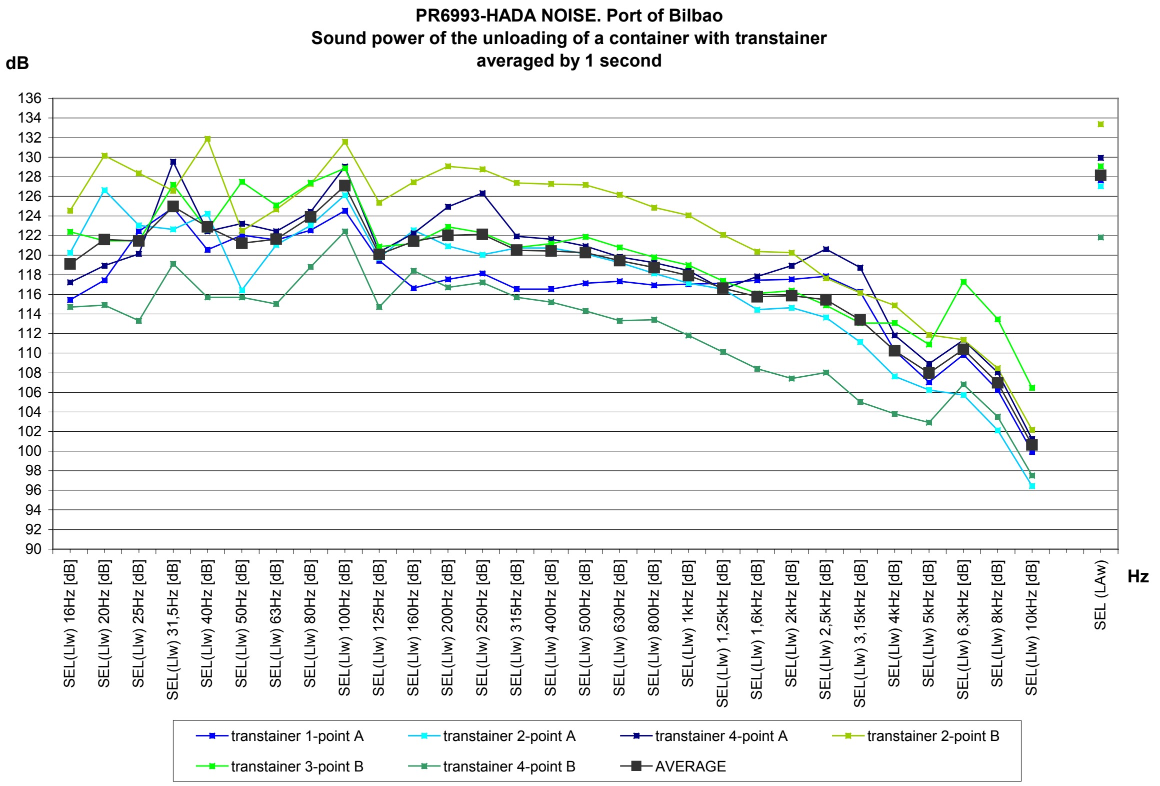
- *Container movement with transtainer and reachstakers*

The transtainer cranes are mainly used for:

- Storing containers that arrive by truck. The crane picks up the container from the truck and piles it up on a dock.
- Loading containers on trucks for highway transportation or for bringing them nearer to the wharf so that a portainer can put them on a boat.
- At last, it is sometimes necessary to relocate containers on docks. When the containers are full, this operation must be carried out with transtainers.

The usual process is the following: the crane comes down to pick up a container from the dock, hoists it and, once it arrives at the truck height, it goes down to put the container on the truck which waits with its engine ticking over. For the unloading process, the handling is the same but in reverse order.

The average time to execute this cycle is very much variable; the sound power (in dB) integrated by 1 second was therefore calculated as follows:



The average power of the container loading cycle integrated by 1 second in bands per octave, is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	SEL LAW [dBA]
SEL(Lw) [dB]	121	122	124	121	119	117	113	109	109	129

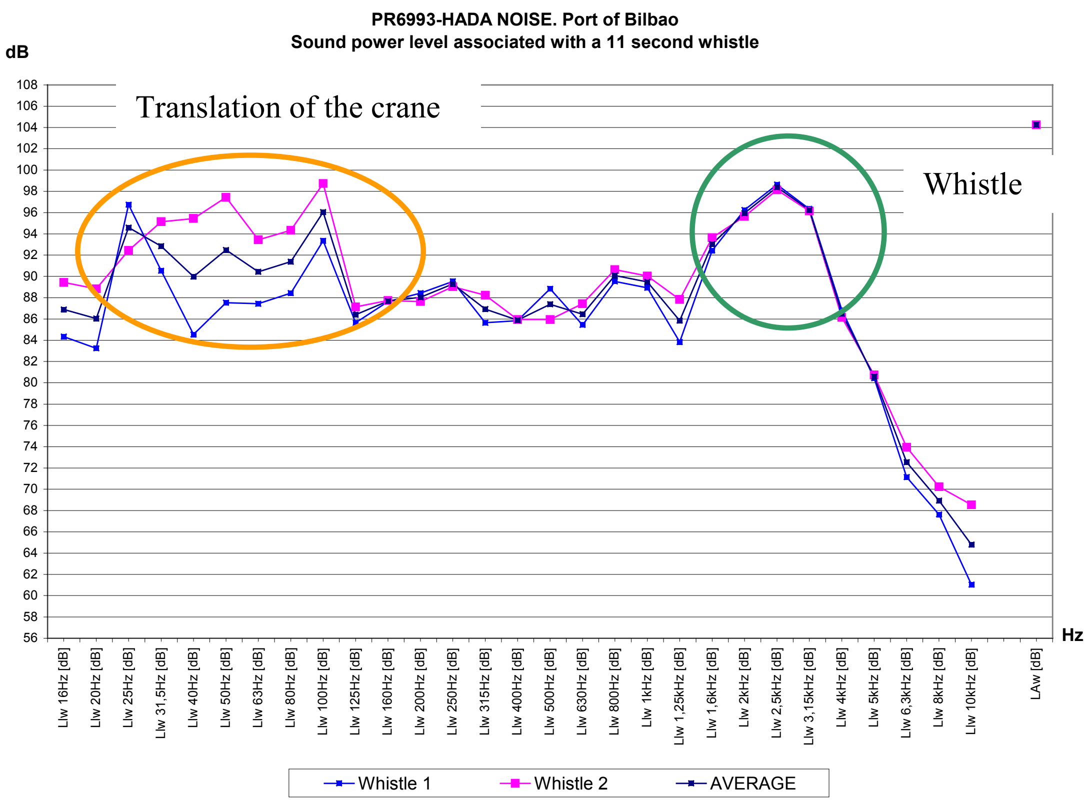
Empty containers movement activities are also part of the operations on docks and are carried out with reachstakers. Docks have a reserved zone for the storage of empty containers. The reachstaker movement acoustic emission was characterised. The sound power related to this source is displayed as follows:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Lw [dB]	64	69	68	66	64	66	63	56	46	70

Due to the variability of operations and handling that occur on the dock, all these activities were characterised as sources of area. The powers previously displayed provide the spectrum associated with sound sources. However, in order to assign the power to the zones, they were adjusted. The measured sound levels both from the monitoring equipment situated in ATM and from the specific samplings carried out on the different wharf positions were taken into consideration.

- *Transfer whistle*

Both the portainer and the transtainer use a security whistle. It is a whistle of about 2.5 Hz. In the following graph and table, the spectrum (in dB) of this whistle is shown:



	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Lw [dB]	98	96	97	93	91	94	101	97	75	104

The whistle is not a considerable noise source during the day since other present sound sources cover it up. However, during the night and without any other sound sources, its influence could be significant. Because of the circumstances, this source was studied separately from the rest.

- *Loading and departure of trains*

Part of the load that from the ATM and TMB docks is transported by train. There is a zone intended to load trains on the wharves. The existing sound sources are:

- Container loading on trains
- Train running on wharves

The sound power of both activities is displayed as follows:

The loading activity of containers to trains is similar to the one happening on the wharves with transtainer cranes. However, there is a fundamental difference: the dock source was considered a zone source that included the entire operating zone, whereas the train loading is considered a linear source on all the length of the train.

The estimated container loading average time is 1 minute. A one-minute linear sound power was calculated from the measurements carried out so that the calculated power produced the sound levels of a container loading.

The result of the linear equivalent sound power level of a one-minute loading process is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW [dBA]
Lw [dB]	79	81	77	78	76	74	70	66	56	78

The trains with container that come in and out the ATM and TMB docks move on rails embedded in the ground of the port. The machines which push them have rubber wheels and move at a very low speed. The sound level generated by this activity is therefore also very low. The trains have a security sound signal as well.

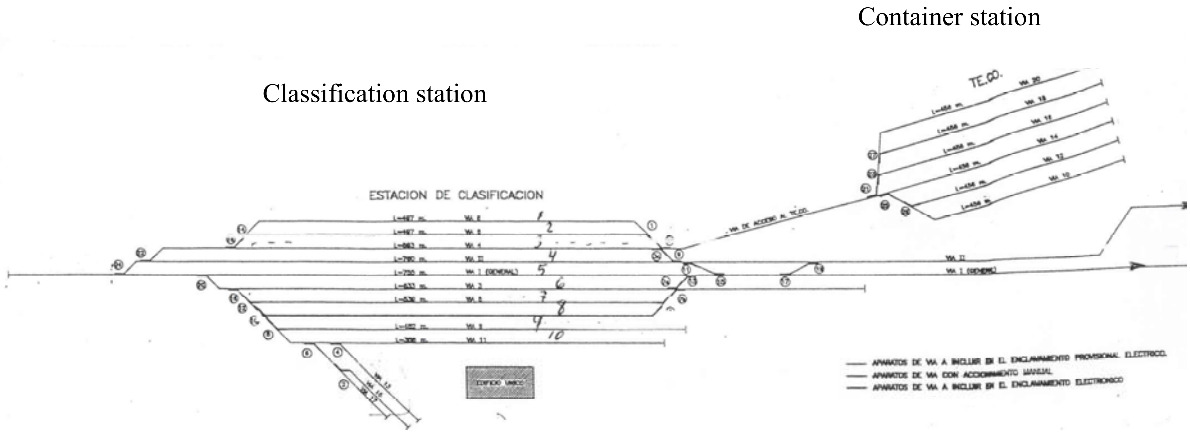
Measurements of sound levels were taken when trains were running and sound levels were taken from this measurement. Just as for the train loading, this sound source is a linear one.

From the adjustment carried out, the sound power per metre of the train passing, integrated by 1 second, is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	SEL (LAW') [dBA/m]
SEL(Lw') [dB/m]	122	124	118	115	119	112	107	102	96	119

5.2.8 RENFE TERMINALS

The RENFE has two terminals in the Port of Bilbao: the classification station and the container station. These two terminals have very different activities.

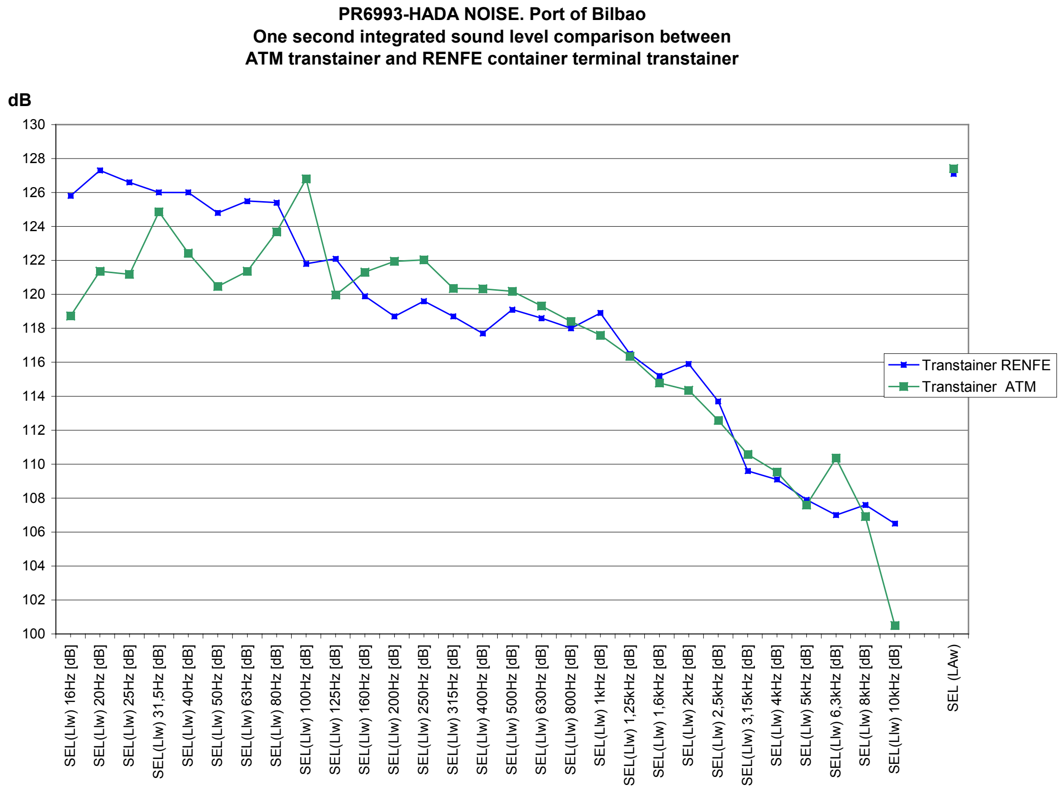


Container station: the containers are stored in this station. Once they are classified, they are loaded on trains with one same destination. The sound source is similar to the ATM y TMB ones and is caused by the movement of containers by a transtainer crane.

The container relocation complete cycle estimated time is approximately 5 minutes. This time is very much variable, reason why it was integrated by one second for the sound power study. Starting from this analysis, the power associated with one second is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	SEL(LAW´) [dBA]
SEL (Lw´) [dB/m]	89	88	84	82	82	81	78	72	70	85

Since the activities achieved in ATM and in the RENFE container station are similar, both activity powers were compared. As we can appreciate in the next graph, both sound power levels are very similar:



Classification station: in this station there are only train movements. The trains of containers coming from the Port arrive and make a locomotive change. They then depart for their final destination.

Sound level measurements were carried out 20 metres away from the trains. The sound power was calculated from the sound pressure levels assimilating it to a linear source. The linear power is shown is the following table:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW´ [dBA/m]
Lw´ [dB/m]	91	94	90	92	86	86	85	84	81	92

5.2.9 BERGÉ WHARF

The Bergé wharf activity characterisation was carried out from the recorded data of the monitoring equipment located outside the V.6 warehouse (modular equipment: FIX EQUIPMENT). The unit supplies data of the equivalent noise level. The Leq levels for the day, evening and night periods are calculated from these data. With these data, the area emission calculation is carried out.

The average levels for three months are displayed in the following table:

LAeq period [dBA]	DAY	EVENING	NIGHT
MARCH	64	56	55
APRIL	65	55	51
MAY	68	58	53

Just as in previous cases, the sound power adjustment of the studied area is achieved by using the calculation model so that the values displayed by the acoustic software adjust to the monitoring equipment averages. The acoustic power per square metre obtained is averaged out for the day period (12 hours). The sound emission of the area is the following:

	31,5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LAW´´ [dBA/m^2]
Lw´´ [dB/m2]	67	67	66	67	63	62	59	56	52	67

5.3 Scenarios of activity and representative emissions

The prior step to the Noise Map production was to define a series of scenarios that could be representative of the activity of the Port of Bilbao. With approximate situations that can usually occur, the followings were considered:

Average diurnal scenario. A general activity in the entire enclosure of the port is considered in that situation.

Average nocturnal scenario. The night activities are usually limited to the ATM and TMB container wharf, as commented previously.

Maximum levels diurnal scenario. This situation is directed towards the study of the sound sources identified as the most likely to cause trouble: ferrous scrap unloading, pig iron unloading and acoustic signals of movement on container wharves.

In order to define the activity of each one of these scenarios, the documentation supplied by the Port Authorities of Bilbao and by the docking enterprises was used. These documents gave information about the average activity carried out in each wharf and about the incoming and outgoing loads.

The sound level characterisation is carried out in terms of average levels representative of the daytime activity, $L_{Aeq,day}$, evening activity $L_{Aeq,evening}$ and night-time activity $L_{Aeq,night}$.

The sound levels caused by these activities during an entire working day are evaluated next. The methodology used is described in the following graph. An average working scenario was extrapolated from the transmitting power of the source (see paragraph 5.2).

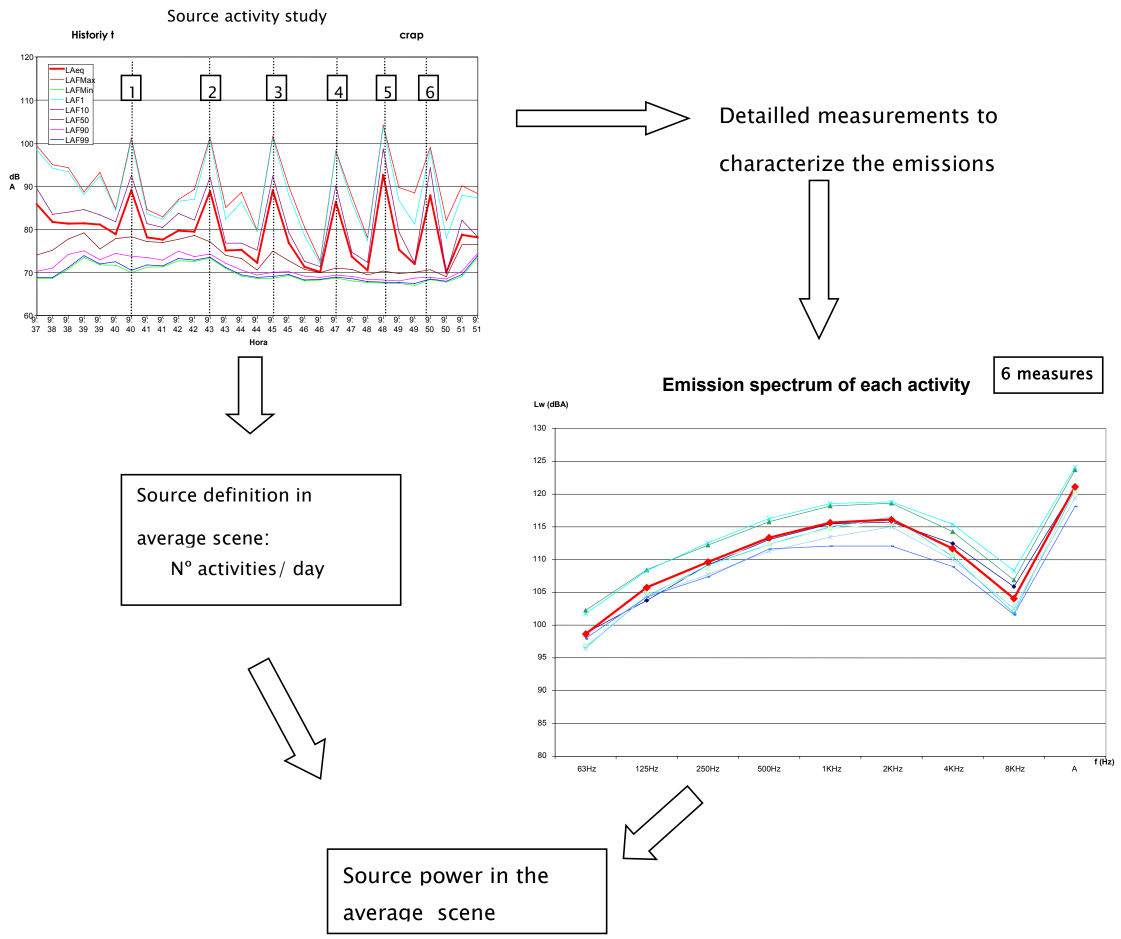


Figure #23. Scheme of the determination process of the acoustic power of a source-scenario

5.3.1 TRUCK ACTIVITY

An average of 1600 trucks come in an out of the Port of Bilbao each day. This activity is supposed to be carried out only during daytime. It implies approximately 134 vehicles per hour during that period. In order to achieve the calculation, the traffic is estimated to be divided up as follows:

TMB terminal: 15% of the total = 20 vehicles per hour.

ATM terminal: 15% of the total = 20 vehicles per hour.

Princesa de España wharf: 15% of the total = 20 vehicles per hour.

Nemar wharf: 15% of the total = 20 vehicles per hour.

Príncipe de Asturias wharf: 10% of the total = 14 vehicles per hour.
Reina Victoria Eugenia wharf: 15% of the total = 20 vehicles per hour.
Bizkaia wharf: 15% of the total = 20 vehicles per hour.

In order to characterise the acoustic effects of this internal truck traffic; the internal roads on which the heavy vehicles move were taken into account, assigning trucks to each section that derive from the previous information. The emission of this traffic source was obtained by applying the French calculation method: Guide du Bruit and NMPB – 96.

5.3.2 RENFE TRAINS

Both the port's incoming and outgoing train running, and the activity that take place in the two RENFE terminals were considered in the scenarios.

Train running

The SRMII Dutch norm for train acoustic emission was applied to analyse the sound levels produced by train running, as recommended by the Directive 2002/49/EC. In order to define the emission, it is necessary to know the number of wagons per hour that move and the type of rail they use. Trains move on a ballast structure until they reach the entrance of the port; they then change to embedded rails once they have entered the port property.

An average of 8 trains per day, 6 during the day, 1 in the evening and 1 at night, come in the port. Taking in account that each train has an average of 18 wagons, the result are the followings:

PERIOD	Wagons/hour
DAY	9 wagons/hour
EVENING	5 wagons/hour
NIGHT	2 wagons/hour

RENFE terminals

Container station

The activity schedule of the container terminal goes from 7:00 AM to 10:00 PM, even though the regular working schedule finishes at 9:00 PM. A minimum of three trains and a maximum of five trains are loaded each day, normally 4 daily.

On average, it is considered that, during the daytime, 7 hours of loading activity are achieved and, during the evening schedule, workers are active for about three hours (form 19:00 until 22:00), the situation being less favourable.

With these premises, the sound power levels are:

LAw day= 83 dB/metre

LA w evening = 84,1 dB/metre

Classification station

5 trains during daytime, 1 in the evening and 1 at night are estimated to come in the classification station each day. Taking these values into account, the calculation of the sound power was carried out during the day, in the evening and at night. The results are the followings:

LAw day= 70 dB/metre

LAw evening = 67 dB/metre

LAw night = 64 dB/metre

The train running between the two stations was also considered in the study. It was considered that all the trains that arrive at the classification station later go to the container station, except the ones that arrive at night since the container station remains close. Therefore, between the stations, the power during the day and the evening is equal to the one calculated for the classification station.

5.3.3 ATM AND TMB

Boat loading and unloading

According to the data supplied by the docking companies, a total amount of 316 ships were operated on the ATM wharf and 536 on the TMB wharf during 2003. Averaging the loaded and unloaded containers from these ships, it is estimated that each boat carried between 150-190 containers.

The loading and unloading time of a boat can vary a lot depending on the boat size and on how many cranes are used. The small ones are unloaded quicker than the large ones (approximately 120 containers are unloaded in 6 hours from a large boat while in a small one, in the same time, about twice as much are unloaded).

Due to the wide variety of situations that can occur, it was decided that, in order to carry out the modelling of ATM and TMB, a common situation that consisted of a large ship unloading with only one crane would be characterised. This situation implied the unloading of approximately 190 containers a day. The sound power in these conditions is the following one:

LA w day= 110 dBA

Considering that the work on docks is also carried out in the evening and at night, and attributing the same working scheme as during daytime, the sound powers are the following ones:

LA w evening = 111 dBA

LA w night = 111 dBA

Movements on wharves

The movements on ATM and TMB docks are mainly characterised by the type of containers handled in each zone of the dock. For the characterisation of the acoustic emission generated during the ATM and TMB terminal container storage zone activities, the total area was divided in parcels associated with the movement of loaded containers (with transtainers) as well as empty containers (with reachstakers). An appropriate emission level was attributed to each one in order to obtain the sound level adjustment given by the monitoring terminal situated on the terrace of the ATM offices and the sound level adjustment of the samples achieved in different locations of the wharf. The said emission is:

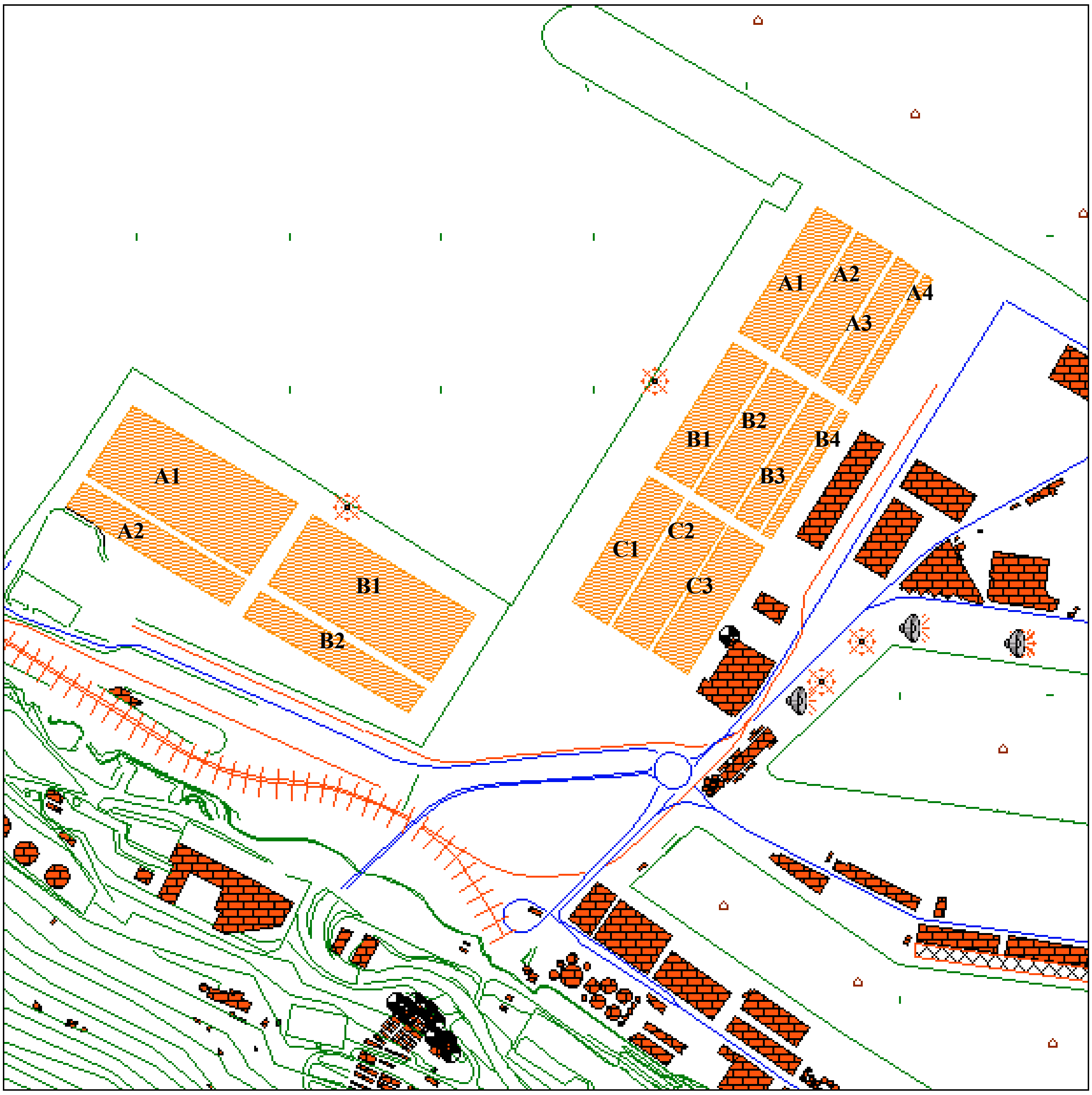
Movements with transtainer: LA w day = 68.2 dBA/m^2

Movements with reachstaker: LA w day = 64.4 dBA/m^2

It is considered that when there is night activity, the transtainers work on loading and unloading boats; the same emission as during the day are therefore assigned to the area sources. However, the reachstaker cranes are only in use during the day; the evening and night emissions are therefore null.

In the next figure, the denomination of the areas defined in the ATM and TMB docks are shown.

The empty containers of the ATM dock are stored in rows 2 (A2, B2 and C2) and 4 (A4, B4 and C4). Reachstaker movements are the main activity of this area whereas in the remaining areas, rows 1 (A1, B1 and C1) and 3 (A3, B3 and C3), the operations are done with transtainers. A similar area distribution was done in TMB, considering that in row 1 (A1 and B1), the movement is due to loaded containers, done with transtainers, and in row 2 the movement is due to empty containers, done with reachstakers.



In order to calculate the sound levels during daytime and night-time, it was considered that there is no activity in the empty container zones during the evening and the night, just as in the C3 zone, since it is the refrigerated container zone.

Train loading

The number of trains that come in and out the docks each week, both in ATM and TMB, are in average 10 and 6. The number of wagons in each train is variable, fluctuating between 18 and 30, each wagon usually transporting one container.

An average of these data is calculated, considering that 2 trains a day leave and one arrives. Considering the average number of wagons, it is estimated that approximately 70 containers are loaded and unloaded during a day. The estimated loading and unloading process is therefore 2 hours a day during daytime.

With these data and the measurements carried out, the sound power value per metre is adjusted:

LA w day= 71 dBA/metre

Train departure

Taking into account that 3 trains a day arrive and depart, just as commented previously, the daily power is extrapolated from the characterisation of one train going by. Therefore, three trains move during the twelve hours of the day; the resultant power is therefore the following one:

LA w day = 76 dBA/metre

5.3.4 FERROUS SCRAP, BRIQUETTES AND PIG IRON

For the calculation of the daily loading and unloading operations of scrap, briquettes and pig iron, it must be considered that a regular working day counts 8 hours.

Scrap loading on trucks	
28 trucks per day	Average Lwday=111 dBA
	Source height = 4 m
Scrap unloading on wharf	
210 unloading by crane per day	Average Lwday=119 dBA
	Source height = 4 m
Briquette unloading on wharf	
280 unloading by crane per day	Media Lwday = 104 dBA
	Source height = 4 m
Pig iron unloading on wharf	
280 unloading by crane per day	Average Lwday=102 dBA
	Source height = 4 m
Pig iron loading on trucks	
105 trucks per day	Average Lwday=122 dBA
	Source height = 4 m

5.3.5 TORO Y BETOLAZA. PAPER UNLOADING

Just as shown in the previous paragraph, the half-wagon loading sound power level integrated by 1 second was calculated. This power is distributed in the whole area between the loading warehouse and the train.

In the diurnal scenario equivalent to an average situation, 1 train a day is loaded, i.e. 20 half-wagons. The resultant sound power per metre square is:

$$Lw = 63\ dBA/m^2$$

5.3.6 PRINCIPE DE ASTURIAS WHARF

Eight hours of work per day (of the twelve included in the daytime period) are considered to calculate the daily emission of the Príncipe de Asturias wharf. The power per square metre is:

$$Lwday/metre^2 = 72\ dBA/m^2$$

5.4 Noise Maps

In accordance with the European Directive 2002/49/EC, representative Noise Maps were created for each one of the defined scenarios. The possible effect of the port activity was extended to the closest residential zones so that a later evaluation could be carried out and, in this case, viable corrective actions could be proposed.

Before beginning with the Noise Map effective modelling, a previous process must be achieved consisting of geographical model preparation. This preparation basically consists of introducing in the acoustic software (IMMI) all the components (field, buildings, obstacles, etc.) that intervene in some way in the sound propagation and whose proper definition directly participates in the quality of the results.

A 3D representation of the generated model can be appreciated in figure #24.

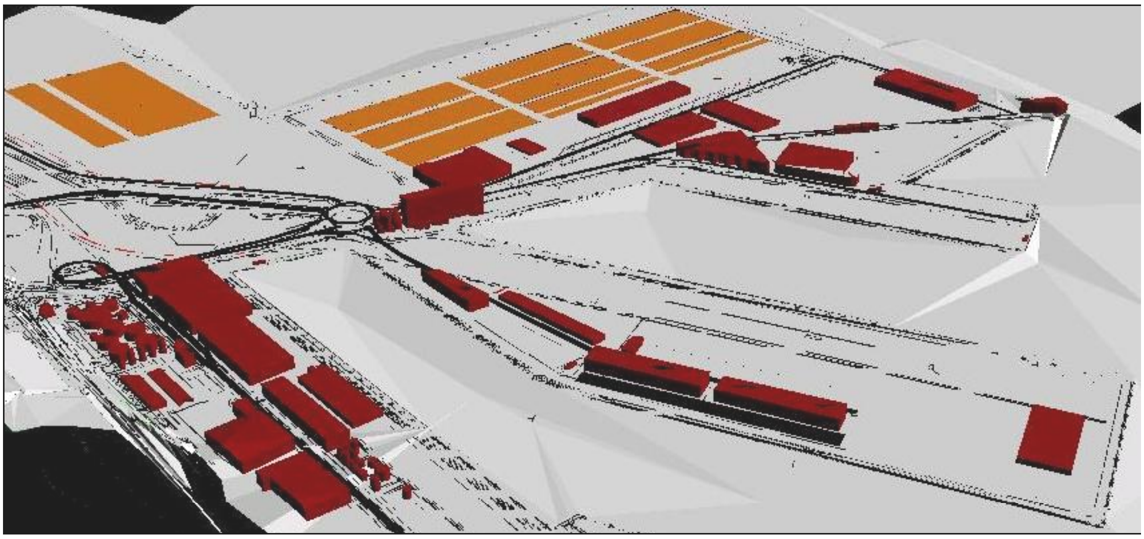


Figure #24: 3D representation of the model where the acoustic calculations are done.

On the base of the defined cartographic model, the introduction of the different noise sources involved was carried out. Specific sources, linear or general, differed in this process, depending on each peculiar emission form. For example, a scrap unloading was represented by a specific source and a road by a linear source.

The most representative locations of each source were looked, both on the ground and in height.

Each one of the noise emission components was identified with a Sound Power level which was obtained from the field measurements, the recording of the two Monitoring Systems units, and from the information concerning the material movements in each case (tons of scrap, number of containers, etc).

Concretely, the noise sources that were taken into account for the Noise Map modelling in each one of the three evaluation periods considered (day, evening and night) are indicated in the next table.

	SOURCES		DAY	Evening	NIGHT
NEMAR WHARF	Ferrous scrap	1 unloading from boat to wharf			
		1 unloading from wharf to truck	X		
	Pig iron	1 unloading from boat to wharf	X		
		1 unloading from wharf to truck	X		
	Briquettes	1 unloading from boat to wharf			
		1 unloading from wharf to truck			
PRINCESA DE ESPAÑA WHARF	Ferrous scrap	1 unloading from boat to wharf			
		1 unloading from wharf to truck	X		
	Pig iron	1 unloading from boat to wharf	X		
		1 unloading from wharf to truck	X		
	Briquettes	1 unloading from boat to wharf			
		1 unloading from wharf to truck			
ADOSADO WHARF	Ferrous scrap	1 unloading from boat to wharf			
		1 unloading from wharf to truck	X		
	Ferrous scrap	2 unloading from boat to wharf	X		
		2 unloading from wharf to truck			
	Pig iron	1 unloading from boat to wharf			
		1 unloading from wharf to truck			
	Briquettes	1 unloading from boat to wharf	X		
		1 unloading from wharf to truck			
BIZKAIA NORTE	Fenwick movement in front of Toro y Betolaza		X		
	Fenwick movement in front of Bergé		X		
TERMINALS ATM	Zones sources with container movements.		X	X	X
	Boat unloading		X	X	X
RENFE	RENFE: train movements		X		

	SOURCES	DAY	Evening	NIGHT
	RENFE: container movements	X	X	
	Incoming trains from town	X	X	X
PRINCIPE DE ASTURIAS WHARF	Fenwick movements. Various	X		
REINA VICTORIA EUGENIA WHARF	Building with interior pig iron movement	X		
THE WHOLE WHARF	Truck movement	X		

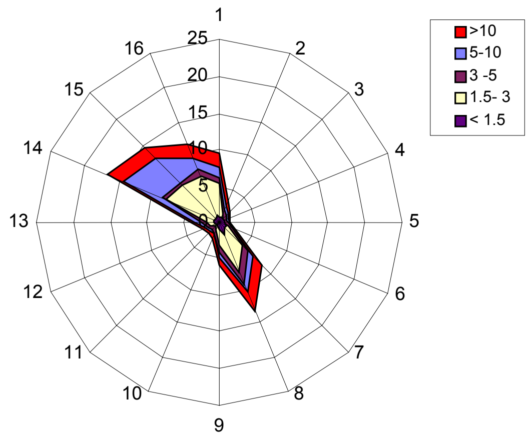
The meteorological conditions, more specifically the wind direction and velocity as well as the thermal inversion effect, are a possible determining factor on the results, both in a modelling process and in a sound level monitoring.

Heeding the recommendations proposed from Europe for the Assessment Directive and Management of Environmental Noise application (2002/49/EC), the calculations in a Noise Map production process must be achieved in favourable wind propagation conditions, blowing in direction of the receiver 50% of the time during the day, 75% during the evening, and 100% during the night. That way, the transmitting source is penalised in a certain way.

Both the propagation conditions recommended by the DIRECTIVE and the LOCAL propagation conditions were considered for the execution of the Noise Maps of the study, since the Port of Bilbao has information about dominant winds at disposal in any of the three assessment periods.

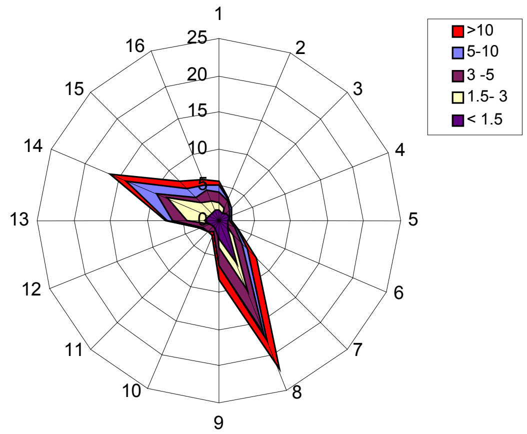
According to the information supplied by the Authorities of the Port of Bilbao, the LOCAL conditions about the wind velocity and direction are represented in the three next graphs:

DAY



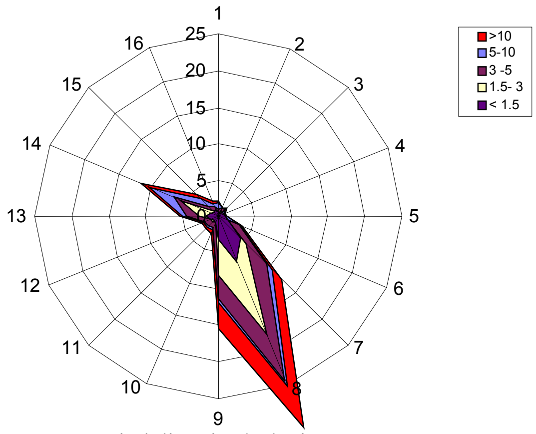
Wind direction/velocity

EVENING



Wind direction/velocity

NIGHT



Wind direction/velocity

The data about the displayed meteorological conditions are extracted form the Basque Government's official data recorded in the meteorological station located in the Nautical School of Santurce. They correspond to the period of the 01/01/2003 to the 12/31/2003.

Once the described preparatives were completed, the Noise Map concrete calculations were processed. The following Maps resulted from the combination of the sources that form the described Scenarios and from the two different meteorological propagation conditions.

Map #1. Average Day Scenario. Directive conditions.
Map #2. Average Evening Scenario. Directive conditions.
Map #3. Average Night Scenario. Directive conditions.
Map #4. Average Entire Day Scenario. Directive conditions.
Map #5. Average Day Scenario. Local conditions.
Map #6. Average Evening Scenario. Local conditions.
Map #7. Average Night Scenario. Local conditions.
Map #8. Average Entire Day Scenario. Local conditions.
Map #9. Nemar Wharf Scrap Maximum Scenario. Local conditions.
Map #10. Princesa de España Wharf Scrap Maximum Scenario. Local conditions.
Map #11. Adosado Wharf Scrap Maximum Scenario. Local conditions.

Map #12. Nemar Wharf Pig Iron Maximum Scenario. Local conditions.
Map #13. Princesa de España Wharf Pig Iron Maximum Scenario. Local conditions.
Map #14. Adosado Wharf Pig Iron Maximum Scenario. Local conditions.
Map #15. ATM Crane Whistle Maximum Scenario. Local conditions.
Map #16. TMB Crane Whistle Maximum Scenario. Local conditions.

The results of these Noise Maps are presented in APPENDIX 3.

As a Noise Map complement, calculations on receivers were carried out for the receivers located on the closest housing development façades facing the port. For each one of them, and for the two propagation conditions, the sound levels corresponding to the day, evening and night periods were obtained.

The results of these calculations are submitted in the following paragraph on the Valuation of the Acoustic Impact.

6 VALUATION OF THE ACOUSTIC IMPACT

Even though Noise Maps allow to quickly value the acoustic impact situation in an extensive zone through the simple observation of the colour graphic scale (established in 5dB range), the detailed valuation of the impact was carried out by means of the modest results obtained by the façade receivers.

6.1 Contributions in façade. Average scenario.

In order to achieve the façade receiver study, the housing development closest to the Port of Bilbao were taken into account. The receivers were situated on different heights, two metres away from the façade, and only the incidental sound was considered.

The minimum height on the field was two metres. From this level, a receiver was located each 2.5 metres along the housing façade. The variation in height of these sound levels can be seen with this study, completing the noise map results that represent them at a 4 metres height, just as specified by the Directive 2002/49/EC.

The valuation study of the impact, based on the receiver level calculations, was structured in three zones.

1. The first one corresponds to the *San Juan Neighbourhood's* housing development.
2. The second one corresponds to the *Regales Neighbourhood's* housing development (facing the Free-Port warehouse zone).
3. The third one corresponds to the housing development situated in front of the *Santurce port roundabout*.

The following information is displayed for each one of these zones:

- Identification plans of the receiving point.
- Sound level table for each point. The day, evening and night values for the propagation with the local meteorological conditions included.
- A comparison between the day sound levels obtained with the local meteorological data is carried out with the application of the data by default suggested by the Directive. The sound level corresponding to the closest monitoring terminal is shown as a reference in each case.
- Table of contribution. Each receiver where the recommended levels were exceeded show the predominant sound sources and indicates its contribution to the overall sound level.

6.1.1 SAN JUAN NEIGHBOURHOOD

In the next graphs, the locations of the façade receivers in the housing of the San Juan neighbourhood are shown:

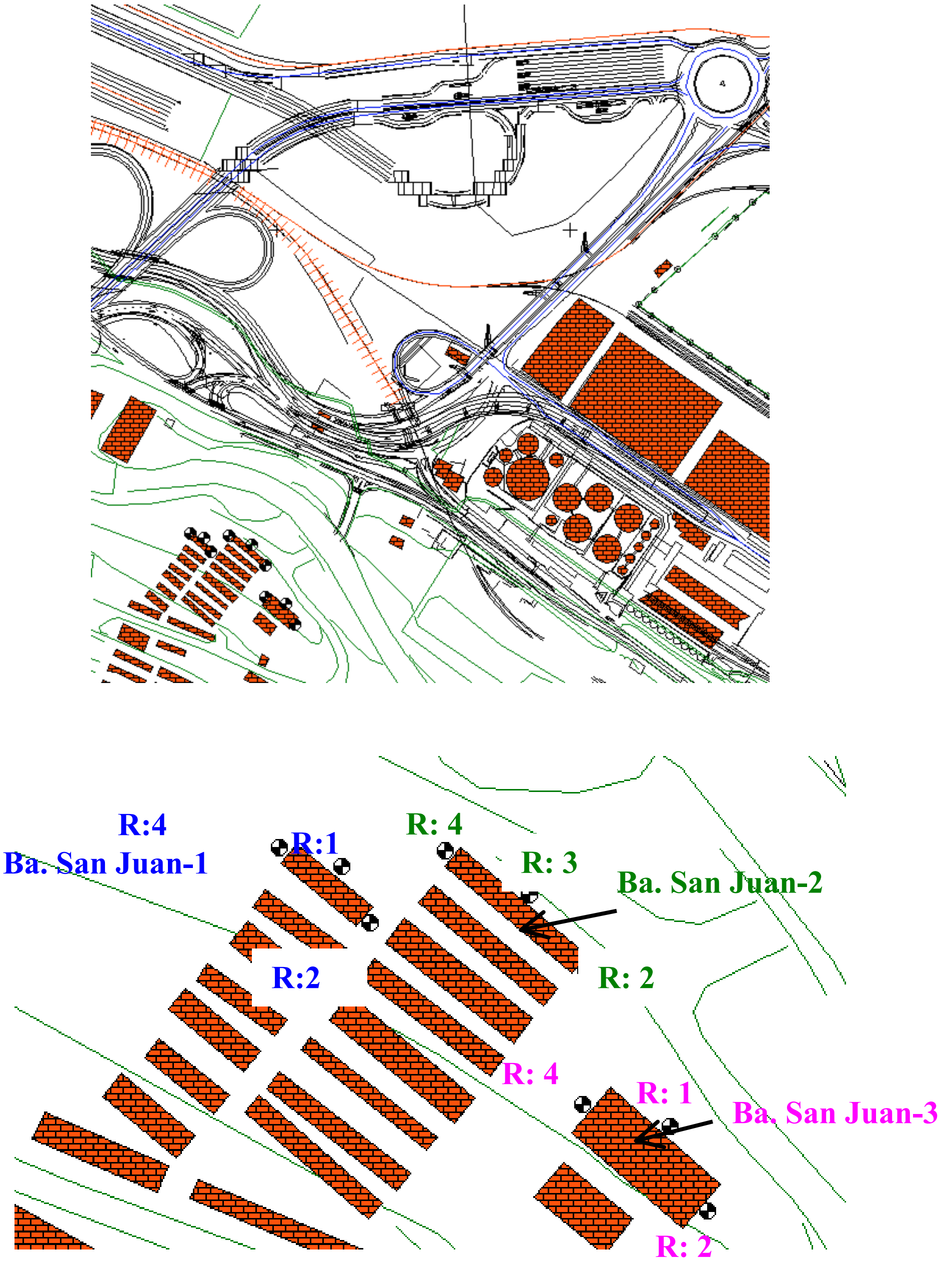


Figure #25. San Juan neighbourhood receiver locations

The housing had two different heights. The receivers were located on various heights. The ones marked GF were situated on the ground floor (2 metres), and the ones marked UF1 were located on the first floor.

The sound levels obtained from the average scenario of the port work with local meteorological conditions are displayed as follows:

RECEIVER	Façade receiver levels LA eq day (dBA)	Façade receiver levels LA eq evening (dBA)	Façade receiver levels LA eq night (dBA)
Ngh. San Juan-1 1 GF	56	46	45
Ngh. San Juan-1 1 UF1	56	46	45
Ngh. San Juan-1 2 GF	53	45	43
Ngh. San Juan-1 2 UF1	54	45	44
Ngh. San Juan-1 4 GF	56	47	45
Ngh. San Juan-1 4 UF1	56	47	45
Ngh. San Juan-2 2 GF	53	44	43
Ngh. San Juan-2 2 UF1	53	46	44
Ngh. San Juan-2 3 GF	56	46	44
Ngh. San Juan-2 3 UF1	56	46	44
Ngh. San Juan-2 4 GF	56	46	45
Ngh. San Juan-2 4 UF1	57	47	45
Ngh. San Juan-3 1 GF	54	45	43
Ngh. San Juan-3 1 UF1	55	45	44
Ngh. San Juan-3 2 GF	50	38	39
Ngh. San Juan-3 2 UF1	50	39	39
Ngh. San Juan-3 4 GF	52	42	42
Ngh. San Juan-3 4 UF1	53	43	42

Taking as a reference the sound limits shown in the Assessment Criteria paragraph, the diurnal sound levels that exceed 55 dBA and the levels that exceed 45 dBA at night would be at the limit.

The receivers in which the sound limits established by the Santurce Regulation are exceeded are highlighted in red.

In general, the limits are exceeded only during the diurnal period except for the San Juan-3 housing development, a bit farther from the source. The sound levels are therefore always inferior, especially the receiver 2 that is screened by the building itself.

During the night, the receivers most exposed (in San Juan-1 and San Juan-2) are on the admissible sound limit (45 dBA).

A comparison between the level obtained by applying the meteorological conditions described in the Directive (condition by default) and by taking the specific condition of the Port of Bilbao was carried out for the diurnal levels.

Reference points (ATM equipment) LA eq day (dBA)	RECEIVER	Façade receiver levels LA eq day (dBA) Meteo: local	Façade receiver levels LA eq day (dBA) Meteo: Directive
LOCAL 67 dBA DIRECTIVE 70 dBA	Ngh. San Juan-1 1 GF	56	57
	Ngh. San Juan-1 1 UF1	56	57
	Ngh. San Juan-1 2 GF	53	55
	Ngh. San Juan-1 2 UF1	54	55
	Ngh. San Juan-1 4 GF	56	57
	Ngh. San Juan-1 4 UF1	56	57
	Ngh. San Juan-2 2 GF	53	55
	Ngh. San Juan-2 2 UF1	53	55
	Ngh. San Juan-2 3 GF	56	57
	Ngh. San Juan-2 3 UF1	56	57
	Ngh. San Juan-2 4 GF	56	58
	Ngh. San Juan-2 4 UF1	57	58
	Ngh. San Juan-3 1 GF	54	56
	Ngh. San Juan-3 1 UF1	55	56
	Ngh. San Juan-3 2 GF	50	52
	Ngh. San Juan-3 2 UF1	50	53

Reference points (ATM equipment) LA eq day (dBA)	RECEIVER	Façade receiver levels LA eq day (dBA) Meteo: local	Façade receiver levels LA eq day (dBA) Meteo: Directive
	Ba. San Juan-3 4 GF	52	54
	Ba. San Juan-3 4 UF1	53	54

In the RECEIVER column, the receiver is identified by the building code, followed by the receiver number and by the annotations GF (ground floor) or UF (upper floor).

According to the conditions of the Directive, the difference in façade receivers is 1-2 dB favourable to the propagation and is 3 dB for the receiver located in ATM.

The conditions of the Directive imply a uniform propagation in all directions. However, the favourable propagation conditions in the Port of Bilbao occur in a particular direction, reason being its influence on the other direction is very much limited. This is why the calculated sound levels are higher when applying the meteorological conditions of the Directive, since the propagation direction (predominant in the Port) does not coincide with the visual line that joins the sound sources and the studied housing.

The contributions to the overall levels in each one of the receivers where the levels were exceeded is shown in the next table. In general, the main source does not strictly belong to the port activity but is associated with the truck traffic in the access points.

RECEIVER	SOURCES	Contributions (dBA)
Ngh. San Juan-1 1 GF	Road entering Ugaldebieta	50,9
	Road leaving Ugaldebieta	50,8
	Train line	44,0
	Overall level	56,0
Ngh. San Juan-1 1 UF1	Road entering Ugaldebieta	50,9
	Road leaving Ugaldebieta	50,8
	Train line	44,0
	Overall level	56,2

RECEIVER	SOURCES	Contributions (dBA)
Ngh. San Juan-1 4 GF	Road entering Ugaldebieta	50,7
	Road leaving Ugaldebieta	50,6
	Train line	44,4
	Overall level	56,
Ngh. San Juan-1 4 UF1	Road entering Ugaldebieta	50,8
	Road leaving Ugaldebieta	50,6
	Train line	44,1
	Overall level	56,1
Ngh. San Juan-2 3 GF	Road entering Ugaldebieta	51,3
	Road leaving Ugaldebieta	51,1
	Entrance roundabout	43,1
	Overall level	56,1
Ngh. San Juan-2 3 UF1	Road entering Ugaldebieta	51,2
	Road leaving Ugaldebieta	51,1
	Roundabout Ugaldebieta	43,2
	Overall level	56,3
Ngh. San Juan-2 4 GF	Road entering Ugaldebieta	51,4
	Road leaving Ugaldebieta	51,3
	Train line	43,8
	Overall level	56,3
Ngh. San Juan-2 4 UF1	Road entering Ugaldebieta	51,4
	Road leaving Ugaldebieta	51,3
	Train line	44,1
	Overall level	56,5

Carrying out an analysis of the sources that contribute to the San Juan-1 and San Juan-2 receivers during the nocturnal period, it was noticed that the main sources were at first TMB (with a 40 dBA contribution) and then the passing of the night train (with a 38 dBA contribution).

Despite the fact that the combined contribution of both sources practically exceeds the admissible sound limit, it is important to remember that they are independant activites and that each of them taken separately respect the appliable sound limits.

- *Relation of the sound levels in the ATM monitoring equipment and façade levels.*

The housing development façade with the highest diurnal sound levels of the San Juan neighbourhood is the named San Juan-2 in which a LAeqday = 57 dBA is recorded. The main sound source of this point does not result from the port activity but from the truck traffic.

In order to study the possible acoustic impact of the port activity, a relation analysis between the levels measured in ATM and the ones received in this housing (San Juan-2) is displayed in the next table.

Considering the average scenario of the estimated activity, the diurnal sound levels recorded in ATM and the contribution of the main sources should correspond to the results of the following table.

SOURCE	Contribution (dBA)
Scrap to wharf (Adosado wharf)	63,8
ATM	61,2
Pig iron to truck (Adosado wharf)	56,5
OVERALL	67,2

From these sources, the contribution registered in the San Juan-2 housing development is shown in the following table:

SOURCE	Contribution (dBA)
SCRAP TO WHARF	40,3
ATM	32,4
PIG IRON TO TRUCK	39,4
TOTAL	43

The main sound sources registered in the ATM monitoring terminal therefore produced 43 dBA in the San Juan Neighbourhood housing façade.

Since the maximum sound level allowed in the housing development façade is 55 dBA, which is 12 dB more than the one produced exclusively by the port activities, it is estimated that, when the ATM unit registers 79 dBA, the one from the San Juan neighbourhood will be approximately 55 dB in façade only with the noise coming from the port.

As for the <u>nocturnal sound levels</u> (from which empty container activity and refrigerated container zone activity are excluded), considering that the activity is concentrated in ATM, the sound levels coming from the different dock working areas registered by the monitoring equipment would be approximately 55 dBA.

SOURCE	Contribution (dBA)
ATM C1	52
ATM B3	48
ATM B1	47,5
TOTAL	55,5

See paragraph 5.3.3 for reference

Analysing the sound levels due to this nocturnal activity registered in the housing, it is considered that the total of these three sources produces a 35,6 dBA sound level in the most exposed building façade (San Juan-2).

Therefore, the measured sound levels of the monitoring equipment should be 10 dB higher than the current one (i.e. higher than 65 dB) in order that the ATM activity produces sound levels higher than the allowed one (45 dB during the night, 10 dB higher than the current level).

In short, the relation of the sound levels allowed on façades with the equivalents recorded in the ATM monitoring equipment is as follows:

Maximum façade level DAY	Level in ATM
55 dBA	79 dBA
Maximum façade level NIGHT	Level in ATM
45 dBA	65 dBA

It must be taken into account that both these established relations and the ones shown in the next paragraphs are the effect of the different sound source combination (with different propagation ways) in such a way that the more uniform the increase of influence will be the better its validity will be.

6.1.2 REGALES NEIGHBOURHOOD

In the next image, the façade receivers located on the housing of the Regales neighbourhood are shown.

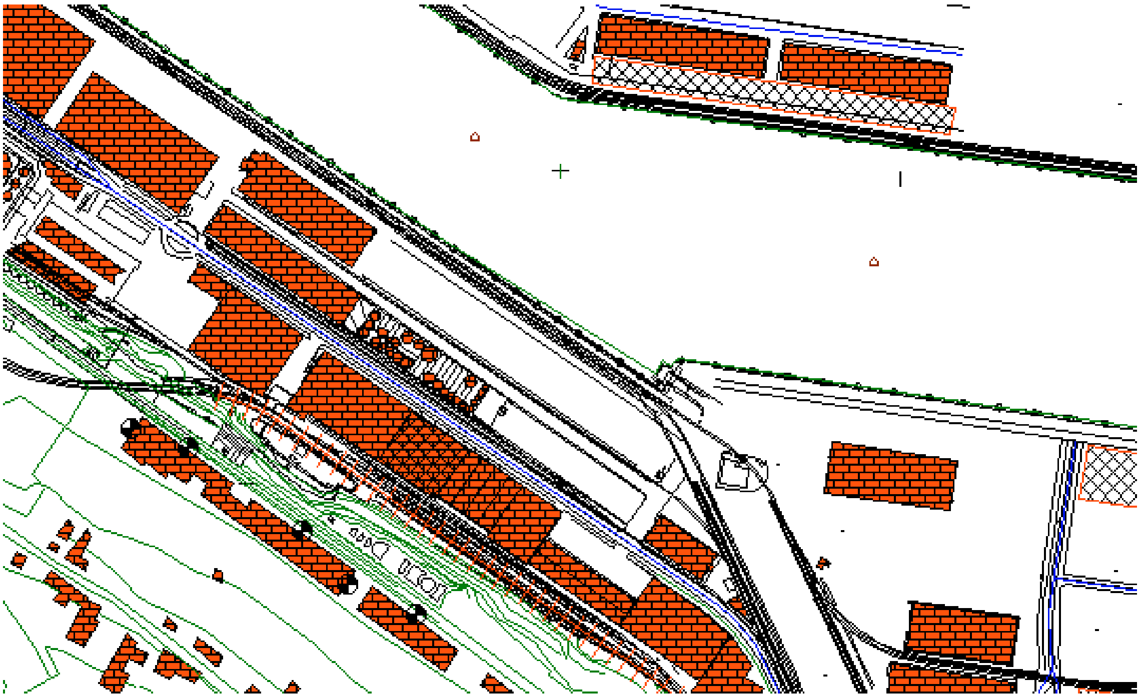


Figure #26. Regales neighbourhood receiver locations.

The housing of this zone has 4 different heights. GF indicates the ground floor and UFN the other heights, N being the floor height. The calculated levels on different height are shown in the table.

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq evening (dBA)	Façade receiver levels LAeq night (dBA)
Ngh. Regales-1 1 GF	45	26	25
Ngh. Regales-1 1 UF1	49	27	25
Ngh. Regales-1 1 UF2	51	28	26
Ngh. Regales-1 1 UF3	52	29	27
Ngh. Regales-1 1 UF4	53	30	28

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq evening (dBA)	Façade receiver levels LAeq night (dBA)
Ngh. Regales-1 12 GF	53	38	38
Ngh. Regales-1 12 UF1	54	38	38
Ngh. Regales-1 12 UF2	54	38	38
Ngh. Regales-1 12 UF3	54	39	38
Ngh. Regales-1 12 UF4	54	40	39
Ngh. Regales-1 13 GF	52	35	34
Ngh. Regales-1 13 UF1	52	36	35
Ngh. Regales-1 13 UF2	54	39	37
Ngh. Regales-1 13 UF3	54	41	39
Ngh. Regales-1 13 UF4	55	41	39
Ngh. Regales-1 17 GF	49	34	33
Ngh. Regales-1 17 UF1	51	35	34
Ngh. Regales-1 17 UF2	53	37	36
Ngh. Regales-1 17 UF3	55	39	38
Ngh. Regales-1 17 UF4	56	41	39
Ngh. Regales-2 2 GF	50	33	32
Ngh. Regales-2 2 UF1	51	35	34
Ngh. Regales-2 2 UF2	53	36	35
Ngh. Regales-2 2 UF3	54	37	36
Ngh. Regales-2 2 UF4	54	38	36

These houses are situated quite close to the source and pretty much high above the sea level. There is a considerable level difference between the different height. The first floor, somewhat more protected from the sources, receives inferior sound levels. However, the higher floors, more exposed, show levels 6-7 dB higher in the most exposed receivers.

There is no impact during the evening and night periods in this housing development. It is a zone where no activity takes place during these periods, the train being the only present source. But since they are situated on a certain height with regards to the track, the blocking effect is sufficient to have no impact.

An analysis of the diurnal sound levels, with consideration for the local meteorological conditions and the default conditions suggested by the Directive is displayed next.

Reference point (equipment in ATM)	RECEIVER	Façade receiver levels LAeq day Local (dBA)	Façade receiver levels LAeq day Directive(dBA)
Local: 67,2 Directive: 69,6	Ngh. Regales-1 1 GF	45	47
	Ngh. Regales-1 1 UF1	49	51
	Ngh. Regales-1 1 UF2	51	52
	Ngh. Regales-1 1 UF3	52	53
	Ngh. Regales-1 1 UF4	53	54
	Ngh. Regales-1 12 GF	53	53
	Ngh. Regales-1 12 UF1	54	55
	Ngh. Regales-1 12 UF2	54	55
	Ngh. Regales-1 12 UF3	54	55
	Ngh. Regales-1 12 UF4	54	55
	Ngh. Regales-1 13 GF	52	52
	Ngh. Regales-1 13 UF1	52	52
	Ngh. Regales-1 13 UF2	54	54
	Ngh. Regales-1 13 UF3	54	55
	Ngh. Regales-1 13 UF4	55	56
	Ngh. Regales-1 17 GF	49	50
	Ngh. Regales-1 17 UF1	51	52
	Ngh. Regales-1 17 UF2	53	54
	Ngh. Regales-1 17 UF3	55	56
	Ngh. Regales-1 17 UF4	56	57
	Ngh. Regales-2 2 GF	50	50
	Ngh. Regales-2 2 UF1	51	52

Reference point (equipment in ATM)	RECEIVER	Façade receiver levels LAeq day Local (dBA)	Façade receiver levels LAeq day Directive(dBA)
	Ngh. Regales-2 2 UF2	53	54
	Ngh. Regales-2 2 UF3	54	55
	Ngh. Regales-2 2 UF4	54	55

In the RECEIVER column, the receiver is identified by the building code, followed by the receiver number and by the annotations GF (ground floor) and UFN (floor or height; N: floor number).

In the Regales neighbourhood, an estimated difference of about 1 dB can also be appreciated between the levels calculated with the local and the Directive meteorological conditions. The levels are lower with the local ones.

The receiver Ngh. Regales-1 17 UF4 receives sound levels above the recommended ones with both meteorological conditions. As shown in the next table, the source that produces these levels corresponds to the sounds of trucks entering the port.

The receiver Ngh. Regales-1 13 UF4 is located on the limit of the evaluation with local condition application and exceeds the limit with the Directive conditions by 1 dB. Obviously, the more the conditions are adjusted to reality, the more precise will be the results.

In this case, the sound levels mainly come from port activities, such as the Free-Port warehouse activities (pig iron operations), the internal truck traffic and the pig iron loading on the Princesa de España wharf.

RECEIVER	SOURCES	Contributions (dBA)
Ngh. Regales-1 13 UF4	Free-Port Port-pig iron (roof)	47,5
	Road facing Free-Port Port	46,8
	Pig iron loading to truck-Princesa de España wharf	46,5
	Overall level	56

Ngh. Regales-1 17 UF4	Free-Port Port-pig iron (roof)	50,8
	Free-Port Port-pig iron (door)	49,3
	Pig iron loading to truck-Princesa de España wharf	46,6
	Overall level	57

- *Relation of the sound levels between the ATM monitoring unit and the façade levels.*

Just as shown previously, the diurnal sound levels recorded on the ATM monitoring equipment and the main source contribution to the conditions of the activity described in the average scenario would be as follows:

SOURCE	Contribution (dBA)
SCRAP TO WHARF	63,8
ATM	61,2
PIG IRON TO TRUCK	56,5
OVERALL	67,2

The contribution of these sources to the sound levels in the most exposed zone of the Regales-1 neighbourhood housing façade are:

SOURCE	Contribution (dBA)
PIG IRON TO WHARF	42,5
SCRAP TO WHARF	35,8
ATM	27,1
TOTAL	43,4

So, 11 dB still remain in order to attain the 55 dBA limit on façade. The sound levels in the ATM receiver would therefore have to be 11 dB higher in order to generate levels higher than the admissible one. In other words, 78 dB levels can be attained.

The analysis is not carried out at night since there is no activity that can have incidence on the façade of this housing development.

Of course, the relation obtained refers to the noise sources with influence on the ATM monitoring equipment, even though the predominant noise sources are different in the case of the Regales neighbourhood. The specific study of these sources would suppose the relocation of one of the Monitoring System terminals for its control.

6.1.3 ENTRANCE ROUNDABOUT OF THE PORT OF SANTURCE

The next graph shows the receivers on the housing façades close to the Port of Bilbao, where the analysis was carried out.

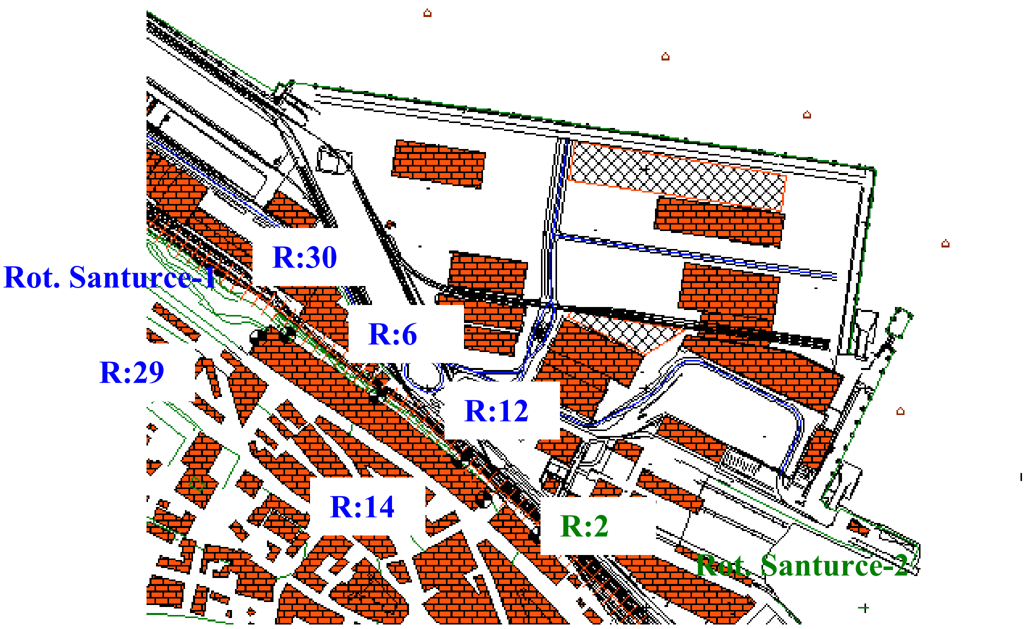


Figure #27. Receiver locations in front of the entrance roundabout of the Port of Santurce

The houses of this area, Ro. Santurce-1 and Rot Santurce-2 are respectively 5 and 7 floor residences. Receivers were installed at each height and the recorded sound levels are the following ones.

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq evening (dBA)	Façade receiver levels LAeq night (dBA)
Ro. Santurce-1 6 GF	58	52	48
Ro. Santurce-1 6 UF1	58	52	48
Ro. Santurce-1 6 UF2	58	52	48
Ro. Santurce-1 6 UF3	58	51	47
Ro. Santurce-1 6 UF4	58	50	46
Ro. Santurce-1 6 UF5	57	50	46

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq evening (dBA)	Façade receiver levels LAeq night (dBA)
Ro. Santurce-1 12 GF	59	55	51
Ro. Santurce-1 12 UF1	59	54	50
Ro. Santurce-1 12 UF2	58	54	50
Ro. Santurce-1 12 UF3	58	53	49
Ro. Santurce-1 12 UF4	57	52	48
Ro. Santurce-1 12 UF5	57	51	47
Ro. Santurce-1 14 GF	51	47	43
Ro. Santurce-1 14 UF1	51	47	43
Ro. Santurce-1 14 UF2	50	47	43
Ro. Santurce-1 14 UF3	50	47	43
Ro. Santurce-1 14 UF4	49	47	43
Ro. Santurce-1 14 UF5	49	46	42
Ro. Santurce-1 29 GF	51	39	36
Ro. Santurce-1 29 UF1	51	40	37
Ro. Santurce-1 29 UF2	51	43	39
Ro. Santurce-1 29 UF3	52	44	40
Ro. Santurce-1 29 UF4	52	44	41
Ro. Santurce-1 29 UF5	52	44	41
Ro. Santurce-1 30 GF	46	34	31
Ro. Santurce-1 30 UF1	47	34	31
Ro. Santurce-1 30 UF2	48	36	33
Ro. Santurce-1 30 UF3	50	38	35
Ro. Santurce-1 30 UF4	52	44	40
Ro. Santurce-1 30 UF5	53	46	43
Ro. Santurce-2 2 GF	57	53	49
Ro. Santurce-2 2 UF1	56	53	49
Ro. Santurce-2 2 UF2	56	53	49
Ro. Santurce-2 2 UF3	56	51	47
Ro. Santurce-2 2 UF4	55	51	47
Ro. Santurce-2 2 UF5	54	51	47

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq evening (dBA)	Façade receiver levels LAeq night (dBA)
Ro. Santurce-2 2 UF6	54	50	46
Ro. Santurce-2 2 UF7	54	50	46

In this case, not as is the Regales neighbourhood, the housing is on the same sea level as the main noise sources. The receivers facing the Bizkaia wharf therefore show higher sound levels on low floors, except for the receivers 29 and 30 which are on the housing's side. They receive a greater influence from other noise sources farther from the Port.

The diurnal and nocturnal sound limits are exceeded on the receivers facing the merchandise train line coming from Santurzi to the RENFE terminal. The fact of exceeding the nocturnal sound levels is more precisely due to the passing of the merchandise train. Any other source contribution is practically non-existent. Besides the merchandise train passing influence, the zone truck internal traffic effect is fundamental in the case of the diurnal period.

The daytime sound levels are shown next with differences between the levels with local meteorological conditions and meteorological conditions recommended by the Directive. As noticeable in these receivers, the difference is much smaller for they are located in the local favourable propagation direction, which coincides with the recommendations of the Directive.

Reference point (Equipment in Bergé) Meteo: Local y Directive	RECEIVER	Façade receiver levels Meteo: local (dBA)	Façade receiver levels Meteo: Directive (dBA)
65 dBA	Ro. Santurce-1 6 GF	58	58
	Ro. Santurce-1 6 UF1	58	58
	Ro. Santurce-1 6 UF2	58	58
	Ro. Santurce-1 6 UF3	58	58
	Ro. Santurce-1 6 UF4	58	58
	Ro. Santurce-1 6 UF5	57	58
	Ro. Santurce-1 12 GF	59	59
	Ro. Santurce-1 12 UF1	59	59
	Ro. Santurce-1 12 UF2	58	58
	Ro. Santurce-1 12 UF3	58	58
	Ro. Santurce-1 12 UF4	57	57
	Ro. Santurce-1 12 UF5	57	57
	Ro. Santurce-1 14 GF	51	51
	Ro. Santurce-1 14 UF1	51	51
	Ro. Santurce-1 14 UF2	50	50
	Ro. Santurce-1 14 UF3	50	50
	Ro. Santurce-1 14 UF4	49	50

Reference point (Equipment in Bergé) Meteo: Local y Directive	RECEIVER	Façade receiver levels Meteo: local (dBA)	Façade receiver levels Meteo: Directive (dBA)
	Ro. Santurce-1 14 UF5	49	49
	Ro. Santurce-1 29 GF	51	52
	Ro. Santurce-1 29 UF1	51	52
	Ro. Santurce-1 29 UF2	51	52
	Ro. Santurce-1 29 UF3	52	53
	Ro. Santurce-1 29 UF4	52	53
	Ro. Santurce-1 29 UF5	52	53
	Ro. Santurce-1 30 GF	46	46
	Ro. Santurce-1 30 UF1	47	47
	Ro. Santurce-1 30 UF2	48	48
	Ro. Santurce-1 30 UF3	50	51
	Ro. Santurce-1 30 UF4	52	52
	Ro. Santurce-1 30 UF5	53	53
	Ro. Santurce-2 2 GF	57	57
	Ro. Santurce-2 2 UF1	56	56
	Ro. Santurce-2 2 UF2	56	56
	Ro. Santurce-2 2 UF3	56	56
	Ro. Santurce-2 2 UF4	55	55
	Ro. Santurce-2 2 UF5	54	55
	Ro. Santurce-2 2 UF6	54	54
	Ro. Santurce-2 2 UF7	54	54

In the RECEIVER column, the receiver is identified by the building code, followed by the receiver number and by the annotations GF (ground floor) and UF (upper floor).

As displayed next, the sources that contribute to the receivers where the daytime limit of 55 dBA is exceeded in façade, as established by municipal regulations.

As indicated, there are two main sources: the internal train passing and truck traffic. These residences are facing a zone where there is no noisy port activity.

RECEIVER	SOURCES	Contributions (dBA)
Ro. Santurce-1 6 GF	Train line	54,7
	Entrance roundabout Santurce	53,8
	Overall level	58
Ro. Santurce-1 6 UF1	Train line	54,3
	Entrance roundabout Santurce	53,8
	Overall level	58
Ro. Santurce-1 6 UF2	Train line	53,8
	Entrance roundabout Santurce	53,7
	Overall level	58
Ro. Santurce-1 6 UF3	Entrance roundabout Santurce	53,6
	Train line	53,2
	Overall level	58
Ro. Santurce-1 6 UF4	Entrance roundabout Santurce	53,4
	Train line	52,7
	Overall level	58
Ro. Santurce-1 6 UF5	Entrance roundabout Santurce	53,3
	Train line	52,2
	Overall level	57
Ro. Santurce-1 12 GF	Train line	57,2
	Entrance roundabout Santurce	51,6
	Overall level	59
Ro. Santurce-1 12 UF1	Train line	56,8
	Entrance roundabout Santurce	50,7
	Overall level	59
Ro. Santurce-1 12 UF2	Train line	56,1
	Entrance roundabout Santurce	50,5

RECEIVER	SOURCES	Contributions (dBA)
	Overall level	58
Ro. Santurce-1 12 UF3	Train line	55,4
	Entrance roundabout Santurce	50,2
	Overall level	58
Ro. Santurce-1 12 UF4	Train line	54,5
	Entrance roundabout Santurce	49,6
	Overall level	57
Ro. Santurce-1 12 UF5	Train line	53,9
	Entrance roundabout Santurce	49,2
	Overall level	57
Ro. Santurce-2 2 GF	Train line	55
	Entrance roundabout Santurce	44,5
	Overall level	57
Ro. Santurce-2 2 UF1	Train line	55,5
	Entrance roundabout Santurce	43,6
	Overall level	56
Ro. Santurce-2 2 UF2	Train line	55,1
	Entrance roundabout Santurce	43,2
	Overall level	56
Ro. Santurce-2 2 UF3	Train line	54,7
	Entrance roundabout Santurce	42,9
	Overall level	56

Sound level relation in the Bergé monitoring equipment and façade levels.

A process to obtain a relation between the sound levels caused by the port of Bilbao in the housing development façades and the data collected by the monitoring equipment located in the Bergé warehouse was carried out. This equipment mainly collects the Bergé activity but also the sound levels that spread from the Princesa de España and Nemar wharves towards the village's housing.

Carrying out an analysis of the sources that contribute to the considered working average scenario on this point, the results were shown that the three main sources were:

SOURCES	Contribution (dBA)
Bergé area	65
Pig iron to truck (Princesa de España wharf)	43,4
Truck traffic (close by the Bergé warehouse)	42,9
OVERALL	65,2

With these premises, the second and third source are almost 20 dB lesser than the Bergé area one. Its overall contribution is therefore null.

The most exposed housing development of the low zone study corresponds to the Santurce-1 roundabout and the least protected receiver of the residence corresponds to number 12. The sound levels produced by Bergé change depending on the height; they start at 27 dBA on the ground floor and go up to 36 dBA on the last floor, which is less screened.

Therefore, the 65 dBA measured in the Bergé equipment after the propagation is no more than 36 in the receiver. In order that the Bergé equipment produces sound levels higher than the ones allowed for house façades, it should register 84 dBA since the maximum daytime level accepted is 55 dBA.

This study was not carried out during nighttime since there is no nocturnal activity that can have an influence on the housing in this port's area.

6.2 Façade levels. Maximum scenarios.

As a final reflection on the impact evaluation, it must be taken into account that, on lots of occasion, what generates real problems is not the fact that a specific average parameter limit (just as the $L_{Aeq,day}$ or the $L_{Aeq,night}$) is exceeded, but that the maximum levels, often related to metallic impacts, whistles, etc, are the real consequences of the neighbourhood's complaints.

A study on the maximum levels suffered by the housing development façades was carried out in this perspective, analysing the two greatest power sources of the port: the ferrous scrap and pig iron unloading. These operations occur in three zones of the port:

- Nemar wharf
- Princesa de España wharf
- Adosado wharf

All the collected sound levels can be found in Appendix 4. An assessment of these sound levels is carried out next.

The following observations can be done in relation to the housing façade maximum sound levels (Lmax) of the Noise Maps obtained for the Maximum Scenarios.

Noise source	Affected zone	Level range (Lmax) in dBA
Crane movement whistles in TMB	Santurce urban area	<35
Crane movement whistles in ATM	Santurce urban area	<35
Pig iron movement on Adosado wharf	San Juan neighbourhood	70
	Regales neighbourhood	60-65; 65-70
	In front of the Santurce entrance roundabout	
Pig iron movement on Princesa de España wharf	San Juan neighbourhood	65-70
	Regales neighbourhood	60-65; 65-70; 70-75
	In front of the Santurce entrance roundabout	60-65; 65-70
Pig iron movement on Nemar wharf	San Juan neighbourhood	55-60
	Regales neighbourhood	60-65
	In front of the Santurce entrance roundabout	55-60; 60-65
Ferrous scrap movement on Adosado wharf	San Juan neighbourhood	55-60; 60-65
	Regales neighbourhood	
	In front of the Santurce entrance roundabout	
Ferrous scrap movement on Princesa de España wharf	San Juan neighbourhood	55-60; 60-65
	Regales neighbourhood	

Noise source	Affected zone	Level range (Lmax) in dBA
	In front of the Santurce entrance roundabout	
Ferrous scrap movement on Nemar wharf	San Juan neighbourhood	50-55
	Regales neighbourhood	55-60
	In front of the Santurce entrance roundabout	50-55; 55-60

The different sound level ranges in a determined zone are displayed according to the façade screening degree in relation to the source.

The highest estimated sound levels correspond to the pig iron loadings and unloadings on the Adosado and Princesa de España wharves. The problem is spread out in the three studied zones, even though the effect is a bit more accentuated in the San Juan neighbourhood (70 dBA) and in specific façades of the Regales neighbourhood (70-75 dBA). However, the influence is logically lower on the Nemar wharf (farther), and moves toward the residential zone situated in front of the port entrance roundabout from Santurce.

As for the scrap loading and unloading operations, the sound levels are lower than the one estimated for the pig iron case. Indeed, for the Adosado and Princesa de España wharves, no sound levels were estimated to be superior to 65 dB(A), and in several façades they were even lower than 60 Db(A). Just as in the case of the pig iron, the distance of the Nemar wharf implies that the maximum levels calculated do not exceed 55 dB(A) in the San Juan neighbourhood and 60 dB(A) in the two other zones.

7 RECOMMENDATION OF CORRECTIVE ACTIONS

Since the acoustic impact situations assessed in accordance with the Santurce municipal regulation were associated with road traffic (trucks) and train running in the three studied zones, any type of remedy focused on to the reduction or elimination of these impact situations should be directed to these two sources.

The existing situation presents the advantage that both noise sources were extensively studied throughout the years, and the possible corrective actions to put in place are well known and can almost be considered as standardised. Among these standard solutions, the acoustic screening design (for both sources), the use of draining surfaces (of low noise) for the roads and the modification of the railway (avoiding welded rail junction) must be established in order to improve anchorages (elastics) by carrying out a proper rail surface maintenance (avoiding roughness) or using the proper type of separated sleepers.

However, on one hand, in the case of the *San Juan neighbourhood*, the fact that the rail section that causes the impact is not located within the port zone poses the problem that the modifications to be carried out would depend on the will of the railway company (RENFE). On the other hand, the railway section that causes the impact is located before the port entrance; again, the modifications would depend on the owner's administration.

In the Regales neighbourhood, the situation of the problem due to the railway is the same. In this case, though, the traffic rail that generates the impact belongs to the Port of Bilbao. This impact is limited to a narrow housing zone, since the Free-Port warehouse buildings serve as a screen. The extension of this effect to the whole housing development of the area turns out to be complex because of the situation between the road and the buildings (situated high up). In any case, the existing spaces would have to be closed, between the Free-Port warehouse buildings, with components (screens) equivalent to the height of these buildings. It must be taken into account that over 5 metre high screen constructions are not recommended.
Finally, in the zone situated *in front of the entrance roundabout of the Port by Santurce*, the train remains the main noise source with the mentioned modification problems, the access

road presenting a similar situation to the one of the Regales neighbourhood.

Considering that the construction of the Serantes tunnel implies the merchandise train running elimination from the section that currently causes part of the main noise impact, it is probable that the resultant future situation gives a valuation of NO acoustic impact. Any modification of the road traffic lanes would therefore be unnecessary.

In any case, regardless of the impact assessment carried out in accordance with the available criteria, it should be beard in mind that all the port activities associated with pig iron and ferrous scrap handling are the cause of the sound levels estimated, which can attain and exceed 70 dB(A), in the closest housing development façades.

Presupposing that the whole activity cannot be achieved on the Nemar wharf (the farthest) only, we recommend that the crane operators be made sensitive to reducing as much as possible the height at which the unloadings are freed.

8 CONCLUSIONS

The work of Introduction of a Follow-up System, Noise Control and Assessment in the Port of Bilbao was established with the double objective of installing a sound level Monitoring Pilot System and of executing a Port Area Noise Map, studying the repercussion on the closest housing development zone of the municipality of Santurce.

As a summary of the results and conclusions obtained from the study, the following points are raised.

The selection, purchase and installation of a Sound Level Monitoring Pilot System in the Port of Bilbao, constituted by two data collection terminals and one storage and information processing central unit, was carried out in accordance with predefined objectives.

Ever since June 2004, the two terminals have continuously collected data that have been used as a support in the Noise Map execution. After the finalisation of the project in March 2005, a complementary report to the current one, in which the final assessment of the monitoring system will be carried out, will be issued. If necessary, it will include modification and/or improvement recommendations (equipment location, parameters to control, etc).

The Noise Map of the port zone was carried out to study the possible bad influence on the closest urban area of the Santurce municipality in which the following steps were followed:

Identification of the main noise sources of the Port of Bilbao by classifying them depending on their potential to generate impacts. Each one of them was documented with the positions they occupied, the parameters of material movements that characterise them (number of containers, number of trucks, number of trains), and was associated with a precise, linear or area noise source type, depending on its way of functioning.

Acoustic characterisation of each one of the sources. From precise sound level measures and from the measurements of the two monitoring stations, the determination of the acoustic power, which will serve as a base in the acoustic model for achieving the maps, was carried out. This power was precisely executed, by metre or square metre, depending on the case.

Scenario Definition. Due to the complexity of the activities that take place in the port (variable in time and position), a series of scenarios which allow the representation of average situations was defined. On the base of three scenarios –day, evening and night–, aspects such as source positions (pig iron, scrap, crane whistles) and meteorological conditions were combined to create a total of 16 Noise Maps.

Two options were concretely considered for the meteorological conditions. On one hand, the proposition from Europe for the application of the Directive about Assessment and Management of Environmental Noise and, on the other hand, the local conditions of wind velocity and direction.

Preparation of a calculation model. Using the IMMI acoustic impact forecast commercial model, a cartographic simulation of the port zone and residences (field, buildings, obstacles) was prepared. The combination of acoustic powers and simulation scenarios was then added. The sound propagation for achieving the Maps was carried out by means of the application of acoustic models suitable for each source type (French road model, Dutch train model, ISO 9613 for industrial sources).

Complementarily to the Map calculation, estimations on a series of receivers located on the most exposed housing building façades was carried out. The information obtained for each one of the receivers served for the execution of the subsequent assessment of the acoustic impact generated by the whole activities of the port, for the establishment a relation between the sound levels recorded in the monitoring terminals as well as in the housing, and finally for determining which sources brought into play were predominant in each case.

From the sound levels calculated on the receivers, and in accordance with the limits established in the specific regulation of the municipality of Santurce, an impact assessment was carried out, taking as reference the diurnal and nocturnal periods. In the following tables, the receivers of the three studied zones in which the impact was estimated is resumed.

San Juan Neighbourhood

RECEIVER	Façade receiver levels LA eq day	Façade receiver levels LA eq evening	Façade receiver levels LA eq night
Ngh. San Juan-1 1 GF	56	46	45
Ngh. San Juan-1 1 UF1	56	46	45
Ngh. San Juan-1 4 GF	56	47	45
Ngh. San Juan-1 4 UF1	56	47	45
Ngh. San Juan-2 3 GF	56	46	44
Ngh. San Juan-2 3 UF1	56	46	44
Ngh. San Juan-2 4 GF	56	46	45
Ngh. San Juan-2 4 UF1	57	47	45

Regales Neighbourhood

RECEIVER	Façade receiver levels LAeq day (dBA)	Façade receiver levels LAeq night (dBA)	Façade receiver levels LAeq evening (dBA)
Ngh. Regales-1 17 UF4	56	41	39

Front of the roundabout in the access from Santurce to the Port.

RECEIVER	Façade receiver levels LAeq day	Façade receiver levels LAeq evening	Façade receiver levels LAeq night
Ro. Santurce-1 6 GF	58	52	48
Ro. Santurce-1 6 UF1	58	52	48
Ro. Santurce-1 6 UF2	58	52	48
Ro. Santurce-1 6 UF3	58	51	47
Ro. Santurce-1 6 UF4	58	50	46
Ro. Santurce-1 6 UF5	57	50	46
Ro. Santurce-1 12 GF	59	55	51
Ro. Santurce-1 12 UF1	59	54	50
Ro. Santurce-1 12 UF2	58	54	50
Ro. Santurce-1 12 UF3	58	53	49
Ro. Santurce-1 12 UF4	57	52	48
Ro. Santurce-1 12 UF5	57	51	47
Ro. Santurce-2 2 GF	57	53	49
Ro. Santurce-2 2 UF1	56	53	49
Ro. Santurce-2 2 UF2	56	53	49
Ro. Santurce-2 2 UF3	56	51	47
Ro. Santurce-2 2 UF4	55	51	47
Ro. Santurce-2 2 UF5	54	51	47
Ro. Santurce-2 2 UF6	54	50	46
Ro. Santurce-2 2 UF7	54	50	46

Even though the acoustic impact assessment criteria of the reference regulation is not included, it was considered important to emphasise the maximum sound levels (Lmax) generated from the pig iron and ferrous scrap loading/unloading activities whose specific effect occasionally cause greater problems than a continuous noise level.

Since the source contribution study allowed to identify the road traffic (trucks) and the train running as the main sources causing acoustic impact, and paying attention to the difficulties described in the report to act on them, the recommendations of corrective actions focuses on trying to avoid as much as possible the production of maximum levels estimated by means of the promotion of good habits from the operators in charge of the handled material, ensuring that the unloading height be as low as possible within the limits of technical viability.

As a final evaluation, all the activities that take place in the Port of Bilbao do not generally mean a noticeable acoustic impact situation (demonstrated by the lack of local complaints), even more if it is taken into account that the assessment limits (Santurce regulation) of 55 dB(A) during the day and 45 dB(A) during the night are lesser than the ones usually considered in the new infrastructure impact assessments or as an example in the Environmental Protection Organisation of Bilbao.

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December 2004

Nagore Tellado Laraudogoitia
Construction and Environment
Acoustic Department

José Luis Eguiguren
Construction and Environment
Acoustic Department

9 APPENDIX 1. MONITORING SYSTEM ANALYSING EQUIPMENT SPECIFICATIONS.

Technical characteristics of the 4441 analyser.

The most important technical characteristics of the 4441 analyser:

Standard: Type 1 IEC 60651 (79) (UNE equivalent)
Type 1 IEC 60804 (85) (UNE equivalent)

Frequency range: 31,5 Hz to 8 kHz in 1/1 octaves
16 Hz to 12,5 kHz in 1/3 octave

Measurement range: Dynamic range of 80/110 dB with adjustable depth scale

Reference range: 30 to 110 dB

Detectors: Parallel detector in each measure:
A Weighting: in large band, with 3 exponential temporal weightings (F, S and I), one linear weighting channel and one peak detector.
Weighting C or L: same as weighting A
1/1 y 1/3 octave bands: with A, C or L, with linear average channel and an exponential detector (F or S).
Saturation detector for every channel.

Background noise: 16,6 dB(A), typical

Measurement functions: L_{eq}, L_{max}, L_{min}, SPL, L_{inst}, SEL, L_{peak}, MaxP, L_N, %Saturation, %Subgame, for large band, plus L_{eq}, L_{max} and L_{min} and SPL for any frequency band.

Calibration: Acoustic (external), Electrical (internal), CIC.

Acoustic calibration: Reference level: 94 dB
Free field conditions
Frontal incidence
Reference frequency: 1 kHz
Temperature of reference: 20ºC
Reference range: 30 a 110 dB

Electrical calibration: Adaptor WA0302

	15 pF microphone equivalent impedance
Time of measure:	from 1 s to 99h:59m:59s, in 1 second periods
Clock:	Internal clock with precision better than 1 minute a month
Output:	2 independent auxiliary outputs
	1 input/output RS232 to 38400 baud series
Feed:	6 LR alkaline batteries, or,
	External 10 – 14 volts source, 3,5 W
Weight:	1,2 kg. Including batteries
Dimensions:	375x120x52 mm.

Environmental conditions:

Less than 0,5 dB influence between –10ºC and +50ºC for working conditions. The same variation for the humidity range included between 30%RH and 90%RH

Technical characteristics of the 2238F analyser

Standards: Type 1 IEC651 and IEC804 and its equivalent Type1UNE 20 464 and 20493. IEC 1672 Draft Class 1 and its equivalent EN 60672

Microphone: B&K model 4188 ½" Free field Prepolarized. 30dB ref 1v/Pa nominal sensitivity. Frequency range: 8Hz to 16Kz.

Preamplificator: Allows the use of 3,10 and 30 m extension cables

Measuring range: 80 dB linear range.
Measurements range: 20 to 140 dB.

Detectors: Two RMS (Fast, Slow, Impulse) simultaneous detectors and Peak with independent weightings (A,C, Lin).

Measurements: Leq (A or C), Lp (A, C or Lin), LAE, Lmax, (A or C y F, S or I), Lmin (A or C y F, S or I), Lpeak, Lmaxpeak, Dose, Saturation, Low range, Time.

Filters: Class1 IEC 1260 compliant, equivalent to EN 61260.
9 filters of octave that include 31,5 Hz to 8Kz. 29 filters of 1/3 of octave that include from 20Hz to 12,5Khz.
Includes two measurements ranges (80 y 90dB)
RMS detectors with time constancy (F, S, I) eligible

Memory: 2 Mb for any measured parameter, includes date and hour, except for instantaneous.

Control: Manual or preselected in the range between 1s and 24h. Includes measurement automatic storage.

Calibration: With any B&K calibrator. Stores the initial calibration for its comparison to the following ones and memorises up to 20 calibrations.

Output: AC with LEMO connector. Weighted or not; 1V level for end of scale. DC with LEMO connector. Proportional RMS signal value, level from 0 to 4V DC (50mV/dB).

Interface: RS232 compliant to EIA 574. With 9 pins connector with transmission speed up to 19200b. For communication and up to 115200b. For file unloading onto computer.

Feed: With LR6/AA alkaline batteries or external feeder from net.

Dimensions: 275 X 97 X41mm and 460 g. (including batteries).

Included accessories: Communication cable to computer (AO1386).
Transport bag (KE0323).
Wind screen (UA1236).
Data unloading program (WBK link).
Alkaline batteries.

10 APPENDIX 2: SOUND POWER LEVEL OF THE SOURCES

The sound power of the different noise sources present in the port area of Bilbao, that were calculated from the field measurements and that served of base for the acoustic modelling process carried out, are displayed in the next table.

An Access file is complementarily included with the current report. Each one of the considered emission spectra is included in the file.

11 APPENDIX 3. NOISE MAPS.

The 16 Noise Maps obtained from the modelling process are included.

1. Map #1. Average Day Scenario. Directive conditions.
2. Map #2. Average Evening Scenario. Directive conditions.
3. Map #3. Average Night Scenario. Directive conditions.
4. Map #4. Average Entire Day Scenario. Directive conditions.
5. Map #5. Average Day Scenario. Local conditions.
6. Map #6. Average Evening Scenario. Local conditions.
7. Map #7. Average Night Scenario. Local conditions.
8. Map #8. Average Entire Day Scenario. Local conditions.
9. Map #9. Nemar Wharf Scrap Maximum Scenario. Local conditions.
10. Map #10. Princesa de España Wharf Scrap Maximum Scenario. Local conditions.
11. Map #11. Adosado Wharf Scrap Maximum Scenario. Local conditions.
12. Map #12. Nemar Wharf Pig Iron Maximum Scenario. Local conditions.
13. Map #13. Princesa de España Wharf Pig Iron Maximum Scenario. Local conditions.
14. Map #14. Adosado Wharf Pig Iron Maximum Scenario. Local conditions.
15. Map #10. ATM Crane Whistle Maximum Scenario. Local conditions.
16. Map #10. TMB Crane Whistle Maximum Scenario. Local conditions.

12 APPENDIX 4: MAXIMUM LEVELS ON FAÇADE

This appendix displays the maximum levels corresponding to the different Maximum Scenarios studied for each façade receiver and each building height considered.

Table 1: Maximum levels on façade. Scrap loading and unloading to wharf. Nemar Wharf.

RECEIVER	LA MAX (DBA)
Ngh.San Juan-1 1 GF	50
Ngh.San Juan-1 1 UF1	50
Ngh.San Juan-1 2 GF	47
Ngh.San Juan-1 2 UF1	50
Ngh.San Juan-1 4 GF	50
Ngh.San Juan-1 4 UF1	50
Ngh.San Juan-2 2 GF	50
Ngh.San Juan-2 2 UF1	50
Ngh.San Juan-2 3 GF	50
Ngh.San Juan-2 3 UF1	50
Ngh.San Juan-2 4 GF	50
Ngh.San Juan-2 4 UF1	50
Ngh.San Juan-3 1 GF	50
Ngh.San Juan-3 1 UF1	50
Ngh.San Juan-3 2 GF	50
Ngh.San Juan-3 2 UF1	50
Ngh.San Juan-3 4 GF	50
Ngh.San Juan-3 4 UF1	50

RECEIVER	LA MAX (DBA)
Ngh.Regales-1 1 GF	51
Ngh.Regales-1 1 UF1	52
Ngh.Regales-1 1 UF2	53
Ngh.Regales-1 1 UF3	55
Ngh.Regales-1 1 UF4	56
Ngh.Regales-1 12 GF	54
Ngh.Regales-1 12 UF1	54
Ngh.Regales-1 12 UF2	54
Ngh.Regales-1 12 UF3	54
Ngh.Regales-1 12 UF4	54
Ngh.Regales-1 13 GF	42
Ngh.Regales-1 13 UF1	43
Ngh.Regales-1 13 UF2	49
Ngh.Regales-1 13 UF3	58
Ngh.Regales-1 13 UF4	58
Ngh.Regales-1 17 GF	48
Ngh.Regales-1 17 UF1	51
Ngh.Regales-1 17 UF2	52
Ngh.Regales-1 17 UF3	57
Ngh.Regales-1 17 UF4	57
Ngh.Regales-2 2 GF	51
Ngh.Regales-2 2 UF1	51
Ngh.Regales-2 2 UF2	52
Ngh.Regales-2 2 UF3	54
Ngh.Regales-2 2 UF4	56

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	46
Ro. Santurce-1 6 UF1	50
Ro. Santurce-1 6 UF2	51
Ro. Santurce-1 6 UF3	51
Ro. Santurce-1 6 UF4	51
Ro. Santurce-1 6 UF5	51
Ro. Santurce-1 12 GF	50
Ro. Santurce-1 12 UF1	51
Ro. Santurce-1 12 UF2	51
Ro. Santurce-1 12 UF3	51
Ro. Santurce-1 12 UF4	51
Ro. Santurce-1 12 UF5	51
Ro. Santurce-1 14 GF	40
Ro. Santurce-1 14 UF1	40
Ro. Santurce-1 14 UF2	40
Ro. Santurce-1 14 UF3	40
Ro. Santurce-1 14 UF4	40
Ro. Santurce-1 14 UF5	39
Ro. Santurce-1 29 GF	52
Ro. Santurce-1 29 UF1	52
Ro. Santurce-1 29 UF2	52
Ro. Santurce-1 29 UF3	53
Ro. Santurce-1 29 UF4	54
Ro. Santurce-1 29 UF5	56
Ro. Santurce-1 30 GF	41
Ro. Santurce-1 30 UF1	42
Ro. Santurce-1 30 UF2	45
Ro. Santurce-1 30 UF3	51

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	51
Ro. Santurce-1 30 UF5	52
Ro. Santurce-2 2 GF	49
Ro. Santurce-2 2 UF1	49
Ro. Santurce-2 2 UF2	50
Ro. Santurce-2 2 UF3	49
Ro. Santurce-2 2 UF4	49
Ro. Santurce-2 2 UF5	49
Ro. Santurce-2 2 UF6	50
Ro. Santurce-2 2 UF7	53

Table 2: Maximum levels on façade. Scrap loading and unloading to wharf. Princesa de España Wharf

RECEIVER		LA MAX (DBA)
Ngh.San Juan-1	1 GF	55
Ngh.San Juan-1	1 UF1	55
Ngh.San Juan-1	2 GF	45
Ngh.San Juan-1	2 UF1	54
Ngh.San Juan-1	4 GF	56
Ngh.San Juan-1	4 UF1	56
Ngh.San Juan-2	2 GF	61
Ngh.San Juan-2	2 UF1	61
Ngh.San Juan-2	3 GF	58
Ngh.San Juan-2	3 UF1	58
Ngh.San Juan-2	4 GF	54
Ngh.San Juan-2	4 UF1	54
Ngh.San Juan-3	1 GF	62
Ngh.San Juan-3	1 UF1	62
Ngh.San Juan-3	2 GF	61
Ngh.San Juan-3	2 UF1	61
Ngh.San Juan-3	4 GF	62
Ngh.San Juan-3	4 UF1	62

RECEIVER	LA MAX (DBA)
Ngh.Regales-1 1 GF	45
Ngh.Regales-1 1 UF1	54
Ngh.Regales-1 1 UF2	54
Ngh.Regales-1 1 UF3	54
Ngh.Regales-1 1 UF4	54
Ngh.Regales-1 12 GF	60
Ngh.Regales-1 12 UF1	60
Ngh.Regales-1 12 UF2	60
Ngh.Regales-1 12 UF3	60
Ngh.Regales-1 12 UF4	61
Ngh.Regales-1 13 GF	55
Ngh.Regales-1 13 UF1	56
Ngh.Regales-1 13 UF2	57
Ngh.Regales-1 13 UF3	57
Ngh.Regales-1 13 UF4	57
Ngh.Regales-1 17 GF	51
Ngh.Regales-1 17 UF1	55
Ngh.Regales-1 17 UF2	56
Ngh.Regales-1 17 UF3	61
Ngh.Regales-1 17 UF4	61
Ngh.Regales-2 2 GF	53
Ngh.Regales-2 2 UF1	55
Ngh.Regales-2 2 UF2	60
Ngh.Regales-2 2 UF3	60
Ngh.Regales-2 2 UF4	60

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	51
Ro. Santurce-1 6 UF1	53
Ro. Santurce-1 6 UF2	54
Ro. Santurce-1 6 UF3	54
Ro. Santurce-1 6 UF4	53
Ro. Santurce-1 6 UF5	53
Ro. Santurce-1 12 GF	52
Ro. Santurce-1 12 UF1	52
Ro. Santurce-1 12 UF2	52
Ro. Santurce-1 12 UF3	52
Ro. Santurce-1 12 UF4	52
Ro. Santurce-1 12 UF5	52
Ro. Santurce-1 14 GF	42
Ro. Santurce-1 14 UF1	42
Ro. Santurce-1 14 UF2	42
Ro. Santurce-1 14 UF3	41
Ro. Santurce-1 14 UF4	41
Ro. Santurce-1 14 UF5	41
Ro. Santurce-1 29 GF	56
Ro. Santurce-1 29 UF1	54
Ro. Santurce-1 29 UF2	54
Ro. Santurce-1 29 UF3	54
Ro. Santurce-1 29 UF4	55
Ro. Santurce-1 29 UF5	55
Ro. Santurce-1 30 GF	44
Ro. Santurce-1 30 UF1	44
Ro. Santurce-1 30 UF2	47
Ro. Santurce-1 30 UF3	54

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	54
Ro. Santurce-1 30 UF5	55
Ro. Santurce-2 2 GF	51
Ro. Santurce-2 2 UF1	51
Ro. Santurce-2 2 UF2	51
Ro. Santurce-2 2 UF3	51
Ro. Santurce-2 2 UF4	51
Ro. Santurce-2 2 UF5	51
Ro. Santurce-2 2 UF6	51
Ro. Santurce-2 2 UF7	57

Table 3: Maximum levels on façade. Scrap loading and unloading to wharf. Adosado Wharf

RECEIVER		LA MAX (DBA)
Ngh.San Juan-1	1 GF	60
Ngh.San Juan-1	1 UF1	60
Ngh.San Juan-1	2 GF	54
Ngh.San Juan-1	2 UF1	58
Ngh.San Juan-1	4 GF	61
Ngh.San Juan-1	4 UF1	61
Ngh.San Juan-2	2 GF	51
Ngh.San Juan-2	2 UF1	51
Ngh.San Juan-2	3 GF	53
Ngh.San Juan-2	3 UF1	53
Ngh.San Juan-2	4 GF	59
Ngh.San Juan-2	4 UF1	59
Ngh.San Juan-3	1 GF	53
Ngh.San Juan-3	1 UF1	53
Ngh.San Juan-3	2 GF	51
Ngh.San Juan-3	2 UF1	51
Ngh.San Juan-3	4 GF	50
Ngh.San Juan-3	4 UF1	50

RECEIVER		LA MAX (DBA)
Ngh.Regales-1	1 GF	48
Ngh.Regales-1	1 UF1	47
Ngh.Regales-1	1 UF2	47
Ngh.Regales-1	1 UF3	47
Ngh.Regales-1	1 UF4	47
Ngh.Regales-1	12 GF	59
Ngh.Regales-1	12 UF1	60
Ngh.Regales-1	12 UF2	62
Ngh.Regales-1	12 UF3	64
Ngh.Regales-1	12 UF4	65
Ngh.Regales-1	13 GF	59
Ngh.Regales-1	13 UF1	58
Ngh.Regales-1	13 UF2	63
Ngh.Regales-1	13 UF3	63
Ngh.Regales-1	13 UF4	63
Ngh.Regales-1	17 GF	54
Ngh.Regales-1	17 UF1	53
Ngh.Regales-1	17 UF2	58
Ngh.Regales-1	17 UF3	59
Ngh.Regales-1	17 UF4	59
Ngh.Regales-2	2 GF	50
Ngh.Regales-2	2 UF1	55
Ngh.Regales-2	2 UF2	57
Ngh.Regales-2	2 UF3	57
Ngh.Regales-2	2 UF4	58

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	54
Ro. Santurce-1 6 UF1	55
Ro. Santurce-1 6 UF2	57
Ro. Santurce-1 6 UF3	57
Ro. Santurce-1 6 UF4	54
Ro. Santurce-1 6 UF5	57
Ro. Santurce-1 12 GF	54
Ro. Santurce-1 12 UF1	55
Ro. Santurce-1 12 UF2	55
Ro. Santurce-1 12 UF3	55
Ro. Santurce-1 12 UF4	55
Ro. Santurce-1 12 UF5	56
Ro. Santurce-1 14 GF	47
Ro. Santurce-1 14 UF1	47
Ro. Santurce-1 14 UF2	47
Ro. Santurce-1 14 UF3	43
Ro. Santurce-1 14 UF4	43
Ro. Santurce-1 14 UF5	43
Ro. Santurce-1 29 GF	57
Ro. Santurce-1 29 UF1	58
Ro. Santurce-1 29 UF2	59
Ro. Santurce-1 29 UF3	60
Ro. Santurce-1 29 UF4	60
Ro. Santurce-1 29 UF5	61
Ro. Santurce-1 30 GF	46
Ro. Santurce-1 30 UF1	46
Ro. Santurce-1 30 UF2	50
Ro. Santurce-1 30 UF3	56

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	56
Ro. Santurce-1 30 UF5	57
Ro. Santurce-2 2 GF	52
Ro. Santurce-2 2 UF1	52
Ro. Santurce-2 2 UF2	52
Ro. Santurce-2 2 UF3	52
Ro. Santurce-2 2 UF4	55
Ro. Santurce-2 2 UF5	52
Ro. Santurce-2 2 UF6	53
Ro. Santurce-2 2 UF7	53

Table 4: Maximum levels on façade. Pig iron loading and unloading to wharf. Nemar Wharf

RECEIVER	LA MAX (DBA)
Ngh.San Juan-1 1 GF	55
Ngh.San Juan-1 1 UF1	55
Ngh.San Juan-1 2 GF	50
Ngh.San Juan-1 2 UF1	55
Ngh.San Juan-1 4 GF	55
Ngh.San Juan-1 4 UF1	55
Ngh.San Juan-2 2 GF	55
Ngh.San Juan-2 2 UF1	56
Ngh.San Juan-2 3 GF	56
Ngh.San Juan-2 3 UF1	56
Ngh.San Juan-2 4 GF	55
Ngh.San Juan-2 4 UF1	55
Ngh.San Juan-3 1 GF	55
Ngh.San Juan-3 1 UF1	55
Ngh.San Juan-3 2 GF	55
Ngh.San Juan-3 2 UF1	55
Ngh.San Juan-3 4 GF	55
Ngh.San Juan-3 4 UF1	55

RECEIVER	LA MAX (DBA)
Ngh.Regales-1 1 GF	57
Ngh.Regales-1 1 UF1	57
Ngh.Regales-1 1 UF2	58
Ngh.Regales-1 1 UF3	60
Ngh.Regales-1 1 UF4	61
Ngh.Regales-1 12 GF	59
Ngh.Regales-1 12 UF1	59
Ngh.Regales-1 12 UF2	59
Ngh.Regales-1 12 UF3	59
Ngh.Regales-1 12 UF4	59
Ngh.Regales-1 13 GF	47
Ngh.Regales-1 13 UF1	48
Ngh.Regales-1 13 UF2	55
Ngh.Regales-1 13 UF3	63
Ngh.Regales-1 13 UF4	63
Ngh.Regales-1 17 GF	54
Ngh.Regales-1 17 UF1	57
Ngh.Regales-1 17 UF2	57
Ngh.Regales-1 17 UF3	62
Ngh.Regales-1 17 UF4	62
Ngh.Regales-2 2 GF	56
Ngh.Regales-2 2 UF1	57
Ngh.Regales-2 2 UF2	57
Ngh.Regales-2 2 UF3	59
Ngh.Regales-2 2 UF4	61

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	52
Ro. Santurce-1 6 UF1	55
Ro. Santurce-1 6 UF2	56
Ro. Santurce-1 6 UF3	56
Ro. Santurce-1 6 UF4	56
Ro. Santurce-1 6 UF5	56
Ro. Santurce-1 12 GF	56
Ro. Santurce-1 12 UF1	56
Ro. Santurce-1 12 UF2	56
Ro. Santurce-1 12 UF3	56
Ro. Santurce-1 12 UF4	56
Ro. Santurce-1 12 UF5	56
Ro. Santurce-1 14 GF	45
Ro. Santurce-1 14 UF1	45
Ro. Santurce-1 14 UF2	45
Ro. Santurce-1 14 UF3	45
Ro. Santurce-1 14 UF4	45
Ro. Santurce-1 14 UF5	45
Ro. Santurce-1 29 GF	56
Ro. Santurce-1 29 UF1	56
Ro. Santurce-1 29 UF2	56
Ro. Santurce-1 29 UF3	57
Ro. Santurce-1 29 UF4	59
Ro. Santurce-1 29 UF5	60
Ro. Santurce-1 30 GF	47
Ro. Santurce-1 30 UF1	47
Ro. Santurce-1 30 UF2	51
Ro. Santurce-1 30 UF3	57

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	57
Ro. Santurce-1 30 UF5	57
Ro. Santurce-2 2 GF	55
Ro. Santurce-2 2 UF1	55
Ro. Santurce-2 2 UF2	55
Ro. Santurce-2 2 UF3	55
Ro. Santurce-2 2 UF4	55
Ro. Santurce-2 2 UF5	55
Ro. Santurce-2 2 UF6	55
Ro. Santurce-2 2 UF7	58

Table 5: Maximum levels on façade. Pig iron loading and unloading to wharf. Princesa de España Wharf

RECEIVER	LA MAX (DBA)
Ngh.San Juan-1 1 GF	63
Ngh.San Juan-1 1 UF1	63
Ngh.San Juan-1 2 GF	60
Ngh.San Juan-1 2 UF1	65
Ngh.San Juan-1 4 GF	63
Ngh.San Juan-1 4 UF1	63
Ngh.San Juan-2 2 GF	64
Ngh.San Juan-2 2 UF1	64
Ngh.San Juan-2 3 GF	64
Ngh.San Juan-2 3 UF1	64
Ngh.San Juan-2 4 GF	63
Ngh.San Juan-2 4 UF1	64
Ngh.San Juan-3 1 GF	63
Ngh.San Juan-3 1 UF1	64
Ngh.San Juan-3 2 GF	63
Ngh.San Juan-3 2 UF1	64
Ngh.San Juan-3 4 GF	63
Ngh.San Juan-3 4 UF1	63

RECEIVER	LA MAX (DBA)
Ngh.Regales-1 1 GF	53
Ngh.Regales-1 1 UF1	66
Ngh.Regales-1 1 UF2	66
Ngh.Regales-1 1 UF3	65
Ngh.Regales-1 1 UF4	65
Ngh.Regales-1 12 GF	64
Ngh.Regales-1 12 UF1	66
Ngh.Regales-1 12 UF2	66
Ngh.Regales-1 12 UF3	67
Ngh.Regales-1 12 UF4	67
Ngh.Regales-1 13 GF	52
Ngh.Regales-1 13 UF1	53
Ngh.Regales-1 13 UF2	61
Ngh.Regales-1 13 UF3	63
Ngh.Regales-1 13 UF4	67
Ngh.Regales-1 17 GF	57
Ngh.Regales-1 17 UF1	61
Ngh.Regales-1 17 UF2	63
Ngh.Regales-1 17 UF3	67
Ngh.Regales-1 17 UF4	67
Ngh.Regales-2 2 GF	59
Ngh.Regales-2 2 UF1	61
Ngh.Regales-2 2 UF2	63
Ngh.Regales-2 2 UF3	63
Ngh.Regales-2 2 UF4	63

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	56
Ro. Santurce-1 6 UF1	58
Ro. Santurce-1 6 UF2	60
Ro. Santurce-1 6 UF3	61
Ro. Santurce-1 6 UF4	61
Ro. Santurce-1 6 UF5	62
Ro. Santurce-1 12 GF	57
Ro. Santurce-1 12 UF1	58
Ro. Santurce-1 12 UF2	58
Ro. Santurce-1 12 UF3	58
Ro. Santurce-1 12 UF4	59
Ro. Santurce-1 12 UF5	61
Ro. Santurce-1 14 GF	49
Ro. Santurce-1 14 UF1	49
Ro. Santurce-1 14 UF2	49
Ro. Santurce-1 14 UF3	49
Ro. Santurce-1 14 UF4	49
Ro. Santurce-1 14 UF5	49
Ro. Santurce-1 29 GF	62
Ro. Santurce-1 29 UF1	62
Ro. Santurce-1 29 UF2	62
Ro. Santurce-1 29 UF3	62
Ro. Santurce-1 29 UF4	62
Ro. Santurce-1 29 UF5	63
Ro. Santurce-1 30 GF	52
Ro. Santurce-1 30 UF1	52
Ro. Santurce-1 30 UF2	54
Ro. Santurce-1 30 UF3	60

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	61
Ro. Santurce-1 30 UF5	63
Ro. Santurce-2 2 GF	56
Ro. Santurce-2 2 UF1	56
Ro. Santurce-2 2 UF2	57
Ro. Santurce-2 2 UF3	57
Ro. Santurce-2 2 UF4	57
Ro. Santurce-2 2 UF5	57
Ro. Santurce-2 2 UF6	57
Ro. Santurce-2 2 UF7	58

Table 6: Maximum levels on façade. Pig iron loading and unloading to wharf. Adosado Wharf

RECEIVER	LA MAX (DBA)
Ngh.San Juan-1 1 GF	68
Ngh.San Juan-1 1 UF1	68
Ngh.San Juan-1 2 GF	69
Ngh.San Juan-1 2 UF1	65
Ngh.San Juan-1 4 GF	68
Ngh.San Juan-1 4 UF1	68
Ngh.San Juan-2 2 GF	66
Ngh.San Juan-2 2 UF1	66
Ngh.San Juan-2 3 GF	70
Ngh.San Juan-2 3 UF1	70
Ngh.San Juan-2 4 GF	68
Ngh.San Juan-2 4 UF1	68
Ngh.San Juan-3 1 GF	63
Ngh.San Juan-3 1 UF1	62
Ngh.San Juan-3 2 GF	63
Ngh.San Juan-3 2 UF1	62
Ngh.San Juan-3 4 GF	60
Ngh.San Juan-3 4 UF1	58

RECEIVER	LA MAX (DBA)
Ngh.Regales-1 1 GF	52
Ngh.Regales-1 1 UF1	54
Ngh.Regales-1 1 UF2	54
Ngh.Regales-1 1 UF3	54
Ngh.Regales-1 1 UF4	54
Ngh.Regales-1 12 GF	64
Ngh.Regales-1 12 UF1	64
Ngh.Regales-1 12 UF2	63
Ngh.Regales-1 12 UF3	63
Ngh.Regales-1 12 UF4	63
Ngh.Regales-1 13 GF	61
Ngh.Regales-1 13 UF1	63
Ngh.Regales-1 13 UF2	63
Ngh.Regales-1 13 UF3	63
Ngh.Regales-1 13 UF4	63
Ngh.Regales-1 17 GF	53
Ngh.Regales-1 17 UF1	58
Ngh.Regales-1 17 UF2	62
Ngh.Regales-1 17 UF3	63
Ngh.Regales-1 17 UF4	63
Ngh.Regales-2 2 GF	60
Ngh.Regales-2 2 UF1	62
Ngh.Regales-2 2 UF2	65
Ngh.Regales-2 2 UF3	66
Ngh.Regales-2 2 UF4	67

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 6 GF	59
Ro. Santurce-1 6 UF1	60
Ro. Santurce-1 6 UF2	61
Ro. Santurce-1 6 UF3	61
Ro. Santurce-1 6 UF4	64
Ro. Santurce-1 6 UF5	65
Ro. Santurce-1 12 GF	61
Ro. Santurce-1 12 UF1	61
Ro. Santurce-1 12 UF2	62
Ro. Santurce-1 12 UF3	62
Ro. Santurce-1 12 UF4	62
Ro. Santurce-1 12 UF5	62
Ro. Santurce-1 14 GF	51
Ro. Santurce-1 14 UF1	51
Ro. Santurce-1 14 UF2	51
Ro. Santurce-1 14 UF3	49
Ro. Santurce-1 14 UF4	49
Ro. Santurce-1 14 UF5	49
Ro. Santurce-1 29 GF	63
Ro. Santurce-1 29 UF1	65
Ro. Santurce-1 29 UF2	65
Ro. Santurce-1 29 UF3	65
Ro. Santurce-1 29 UF4	65
Ro. Santurce-1 29 UF5	65
Ro. Santurce-1 30 GF	52
Ro. Santurce-1 30 UF1	52
Ro. Santurce-1 30 UF2	57
Ro. Santurce-1 30 UF3	62

RECEIVER	LA MAX (DBA)
Ro. Santurce-1 30 UF4	62
Ro. Santurce-1 30 UF5	63
Ro. Santurce-2 2 GF	58
Ro. Santurce-2 2 UF1	58
Ro. Santurce-2 2 UF2	58
Ro. Santurce-2 2 UF3	59
Ro. Santurce-2 2 UF4	59
Ro. Santurce-2 2 UF5	59
Ro. Santurce-2 2 UF6	59
Ro. Santurce-2 2 UF7	61