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NOISE CONTROL FOR A BETTER ENVIRONMENT

SHIPBUILDING AND NEW REQUIREMENTS FOR REDUCTION OF ENVIRONMENTAL IMPACT OF SHIPS: NEW TECHNOLOGICAL CHALLENGES AND BUSINESS OPPORTUNITIES

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ABSTRACT

The new and increasingly demanding requirements of reducing the environmental impact of all types of ships from all countries and Regulatory Institutions such as the new "Green Policy" of the EU, leads to the development of a series of Regulations/Directives which will immediately affect, both the owner and the builders worldwide.This makes it necessary to introduce modifications in the vessel design in order to fulfil these requirements and, ultimately, improve their exploitation avoiding penalties and/or restrictions.

Awareness of some Spanish Owners with these requirements have allowed to the Spanish Shipbuilding to be positioned strategically at the forefront of technology to fulfil these requirements.

This work, after a review of those Directives that affect the ship design, focuses on the presentation of the results obtained in two Ro-Ro Vessels. These vessels, by their design and performances, are a *"technological reference"* in the new scenario of high environmental performance requirements: Noise & Vibrations on board, Noise Radiated to the Harbour and Noise Radiated to the Water.

Key Words: Ships Environmental Impact Reduction; Noise & Vibrations; Underwater Radiated Noise.
INCE Classification of Subject Number:

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1. INTRODUCTION.

The growing society interest in the importance of Control, Monitoring and Improvement of the environment, has been the stimulus for different states to respond to this current demand. As many other countries, the European Union (EU), also sensitive to these claims, has started the so-called "Green Policy", which main target is to establish Directives or/and Requirements to improve and maintain the environment.

In this new "Green Policy", the EU has identified "ambient noise" [1] as one of the most critical factors to control, being all type of transports (land, air and sea) the main polluting agents. As a consequence, Noise and Vibration reduction in all type of transports constitutes one of the main objectives in the environmental improvement policy defined by the EU and the rest of countries involved in improving the environment.

Noise and Vibration emissions caused by vessels have several consequences: first of all, the emissions could lead to crew health disorders; they affect passengers and harbour surrounding residents comfort, as well as the working dynamics of the vessel. In the case of fishing vessels, which are under no regulation in this aspect, there are several statistical studies which reveal rates up to 70% of ear related disorders among the crew. Secondly, known are the problems that some ship owners (national and international ones) have had due to complaints and reports about the excessive noise generated by the vessels when they tie up near highly populated areas.

Furthermore, the high level of Underwater Radiated Noise coming from a high rate of sea transport, and the fact that this aspect "has not been controlled", except for specials vessels (Fishing Research Vessels- FRV), were revealed as the main causes of marine life and dynamic alteration, with its ecological and economic consequences for the marine environment and the coast line. It is experimentally verified that fish escape from these areas due to higher rates of underwater radiated noise as a result of the sea transport increase.

It is important to highlight that the most recent Regulations/Directives as well as the coming ones **warn and oblige** ship owners and vessel operating companies, to adopt all the possible measures that would guarantee workers health in relation to Vibration and Noise and in agreement with the new security and health rules. This is resulting in the incorporation of all these new environmental requirements in all the Contractual Specifications of the new Shipbuilding.

In view of this new and restrictive Environmental Regulatory Framework, that it is supposed to have an impact in the design of the new vessels and consequently in the production costs, it is evident that Shipbuilding as a globalized industry has now a serious dilemma: it can either "look the other way" or "answer efficiently" to this new treat, making (what most would consider "a problem") a "business opportunity "as long as we can "create a value enhancement strategy". For those shipyards that will chose to "answer efficiently", they now face a "new specialized niche in the market" as a difference against their competitors.

In this present work, after a detailed revision of the Current Regulatory Framework and the one that is about to come (that will affect design and cost), it is presented the **Study Case** of the obtained results as a clear evidence of the correct training and preparation of the Spanish Marine Sector, to answer to these new challenges.

2. CASE STUDY: RO-RO NAVANTIA vessels for ACCIONA TRANSMEDITERRÁNEA.

2.1. Description and Main Particulars.

At the end of March and in the middle of August 2010, **NAVANTIA-Factoría de Puerto Real** delivered the RO-RO vessels **"José María Entrecanales"** (C-509) and **"Super-Fast Baleares"** (C-510) to the Spanish company **ACCIONA TRANSMEDITERRÁNEA**. Both last generation units constitute the biggest freighters in the Spanish market. They have been designed to have two weekly rotations in routes between 700 and 800 nautical miles or, alternatively, a weekly rotation in routes of 1.500 nautical miles. The main characteristics of these vessels and their main machinery are collected in the attached **Figure 1**.

Características Principales.	
Eslora Total	209,80 m.
Eslora entre pp.	190,80 m.
Manga de Trazado.	26,5 m.
Puntal a Cbta. Principal.	9,60 m.
Calado de Diseño.	7,00 m.
Calado de Escantillonado.	7,10 m.
Peso Muerto al Calado de Diseño.	9.325 t
Potencia Propulsora.	4 x 10.800 kW a 500 RPM.
Velocidad de Servicio.	26 nudos.
Autonomía.	3.000 m.n.
Capacidad de Carga:	
-Nº de Módulos de 14,3 m.	187
-Nº de Contenedores "mafi".	23
-Nº Coches Cubierta Fija	108
Tripulación y Pasaje.	40 personas.
Clasificación:	BUREAU VERITAS. I ✠ HULL, ✠ MACH, RO-RO PASSENGER SHIP, UNRESTRICTED NAVEGATION, ✠ AUT-UMS, ✠ AUT-PORT, ✠ SYS-NEQ-1, MON-SHAFT INWATER SURVEY.

Características Principales de la Maquinaria Principal	
Motores Principales	
Marca	MAN DIESEL & TURBO.
Modelo	9L 48-60 B.
Potencia Nominal	10.800 kW.
Velocidad de giro Nominal.	500 RPM
Numero de Cilindros.	9
Nº de Ciclos.	4 T
Nº de Unidades	4
Cajas Reductoras	
Marca	RENK
Relación de Reducción.	3,324:1
Nº de Unidades.	2
Hélices	
Diámetro	5.200 mm
Numero de Palas	4
Paso	Variable
Velocidad de Giro Nominal	150 RPM

Figure 1. Main characteristics of the vessels and their main machinery.

Finally as important noise sources in these types of vessels, we can highlight the ventilation of the hold and the engine room. Both vessels have fifty-eight (58) ventilation units, some of them with a capacity of up to 120.000 m^3/h.

2.2. Basic Objectives of the Project. Noise and Vibration Specifications. ISO Standard 2992/2000.

In the contractual specification signed by the shipyard and the ship-owner, a "Noise and Vibration Level" specific section is highlighted and due to its importance for this project, it is shown in these different sections: **1) "A Noise Prediction will be done in different areas of the vessels". 2) "The acceptable Noise levels will be the ones established by the IMO in the A.468 (XII) Resolution [4]". 3) "A noise level measurement will be done in the places and conditions established by the IMO to prove that they do not exceed the limits". 4) "Vibration levels in the cabin, common areas, and public areas for crew and passengers will not be in the zone of "Values which are likely to adverse comments", established by the ISO Standard 6954/2000 [5]". 5)"Exterior noise levels under 80 dB (A), measured according to ISO 2922/2000 [6] with the vessel in operational conditions in the harbour". 6) "A vibration measurement will be done to check that the vessels are fulfilling the previously mentioned rule"**.

Noise and Vibration requirements were set in the following way: **Vibrations** in compliance with **ISO Standard 6954/2000 [5]**. Noise corresponds to **IMO A.468 (XII) Regulation [4]**.

3. PRACTICAL APPLICATION OF THE "NOISE AND VIBRATION COMPREHENSIVE MANAGEMENT" IN THE VESSELS: "JOSÉ MARÍA ENTRECANALES" AND "SUPER-FAST BALEARES".

3.1. General Scope.

The experience based on the excellent results obtained in the "**Silent Vessels**": Oceanographic Vessels **"Miguel Oliver"**, **"Sarmiento de Gamboa"** and the Fishing Research Vessel **"Emma Bardan"**, permits to confirm that the fulfilling of these strict requirements demands a complete development of the methodology of **Total Noise and Vibration Management**, that the author is applying and that includes, in a minimum range, the development of the principle and procedure previously exposed.

With this **"first activity level"** it is intended that the shipyard can develop and exert a "control" over those aspects that, as previously described, are in the scope of the suppliers. The intention with this is to achieve what we call **"contractual sensitivity"** of the suppliers towards the dynamic and acoustic objectives of the project. Its **"no-application"**, leaves the shipyard, in many occasions, "with tight hands" when it comes to finding solutions or countermeasures more economic and technically efficient.

In the **"second level"** of activities, are considered all those aspects that are in direct competence with the shipyard, as it is the supplying of a structure with an appropriate dynamic design: without resonance and enough acoustic isolation to guarantee the minimum requirements. In this section all the simulation techniques are integrated, such as: **A)** Vibration Prediction through Finite Element Method. **B)** Noise level Prediction in the vessel locals through **SEA Method**. **C)** Noise Radiated to Harbour prediction, when required. **D)** Underwater Radiated Noise Prediction, when required.

In the Case Study that we are working on, the development of the **Noise and Vibration Integrated Management** scope has been, as indicated, "partial" focusing only and exclusively on the application of "**Simulation Techniques**" for those aspects required in the Specification: Vibrations, Noise and Noise Radiated to Harbour.

3.2. Vibration Prediction through Finite Element Method in the building of NAVANTIA-Puerto Real C-509 and C-510.

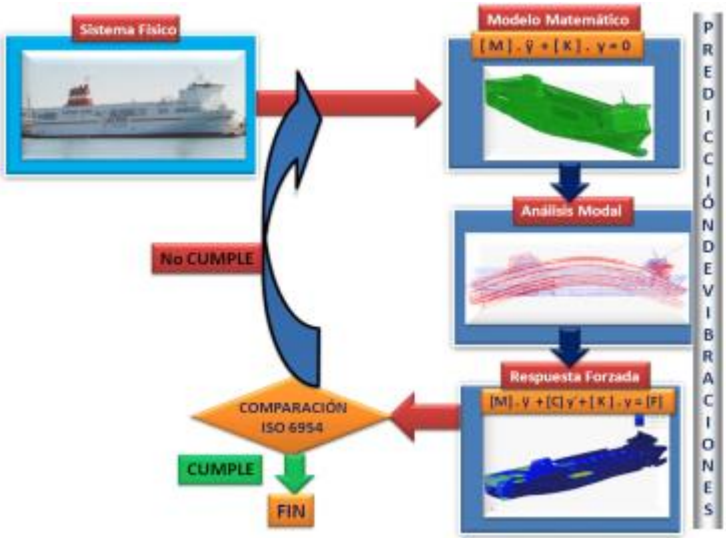

Figure 2. Methodology of the Vibration Prediction.

A mathematical model of calculation through finite element -F.E.M.- was applied, with the intention of avoiding dynamic amplification phenomena due to possible "**Resonance Phenomena**" in the vessel structure, to identify own frequencies and avoid their coincidence with the main excitation sources of the vessel: Forces and

Moments of Main Engines excitation and Forces coming from Pressure Pulses inducted by the propeller on the sternpost.

The application, to this dynamic model of the vessel structure, of the different forces of the excitation source: Main Engines and Propellers, will help use to obtain the “Expected Vibration Levels” in the different areas of all the vessel structure. From the comparison between these “Expected Vibration Levels” with the limits required in the **ISO Standard 6954/2000 [5]** demanded in the specification, decisions will be taken that will allow us to validate the structure from a dynamic behaviour point of view or introduce those structural modifications that guarantee this fulfilment inside the demanded limits. In **Figure 3** we can see a summary of the applied methodology.

3.2.1. Description of the Mathematical calculation model.

To represent the dynamic characteristics (mass and stiffness) of the structure, two-dimensional elements like plate (shell) were mainly applied, capable of admitting distortions in its plane and perpendicular to this, using one-dimensional elements (beam) for the primary structure and struts. Equipment with a weight over 1000 kg has been considered as point masses distributed in the area where beams are supported, with the exception of the main engine and the reduction gear that has been modelled with two-dimensional elements.

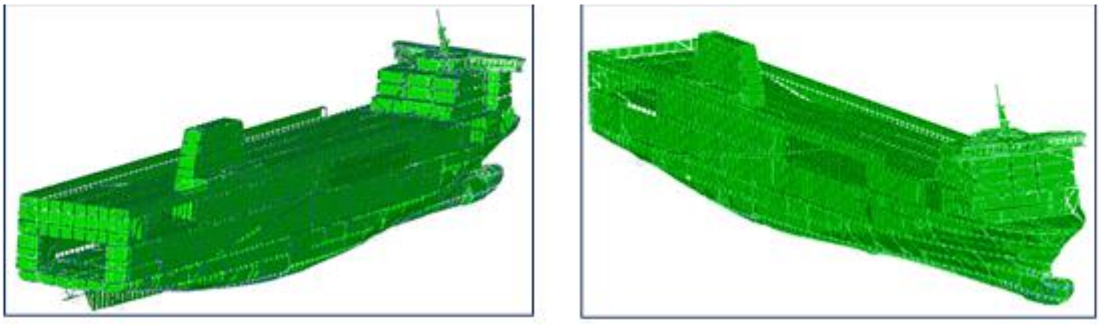

Figure 3. Mathematical Model of Finite Elements.

To do the calculation, it had taken in account ballast and consumer tank filling. In **Figure 3** the mathematical model used can be seen.

3.2.2. Fulfilled calculation.

On the mathematical model, two types of calculations were done, as described in the following lines:

<u>Modal Calculation</u>: Through this calculation were obtained the eigenfrequencies or resonance frequencies of the vessels and its vibration mode shapes. The coincidence between eigenfrequencies and excitation frequencies (propellers and propelling engines) can produce a phenomenon called resonance and then high level of vibration could be produced. This type of calculation is an essential requisite to be able to make the forced response calculation or to predict vibration levels.

<u>Forced response. Vibration levels prediction</u>: This calculation includes the characteristics of the vessel through the modal calculation and the characteristics of the excitation sources (amplitude and frequency) to obtain the expected vibration levels in the vessel structure.

3.2.3. Obtained results.

As previously pointed out, the relative location of these eigenfrequencies in relation to excitation frequencies mainly inducted by the main engines and the propeller, allows a first evaluation of **"resonance risk"** at local and global level.

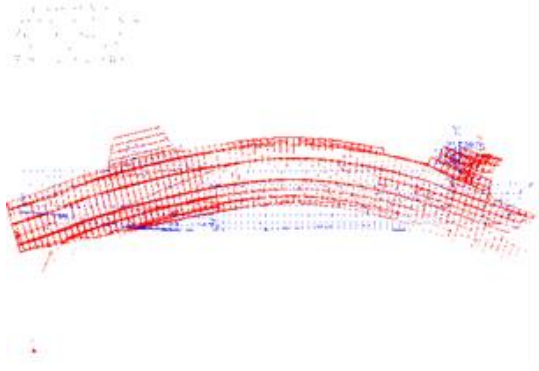

Figure 4. First Vertical Bending Mode Shape. 1,78 Hz.

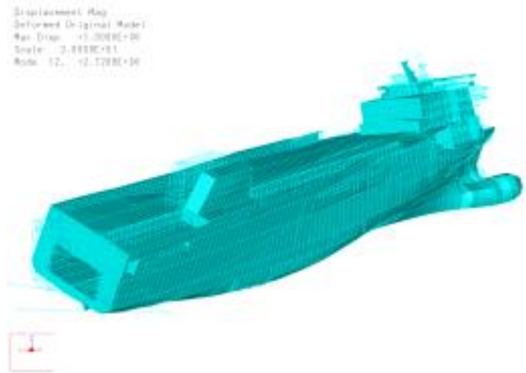

Figure 5. First Torsional Mode Shape. 2,72 Hz.

In **Figures 4** and **5** Vibration modes and shapes associated with the first three modes or eigenfrequencies of the ship-beam obtained, were collected.

3.3. Noise Prediction through SEA Method.

3.3.1. Brief introduction to SEA Method.

To make a noise prediction it is necessary to count on the acoustic excitations and their transmission paths, this means working in high frequency. The **SEA Method (Statistical Energy Analysis)** gives a way to alternative model **FEM** and **BEM**, and to represent the vibratory state of a system. The model represents the means behaviour of a group of similar systems and it also includes an uncertainty factor in the model. The vibratory state is expressed in terms of vibratory energy of individual components. The application of these excitations is expressed in terms of power. And the relation between the excitations and the energy of the elements is expressed in terms of energy flow.

3.3.2. General description of Noise Prediction.

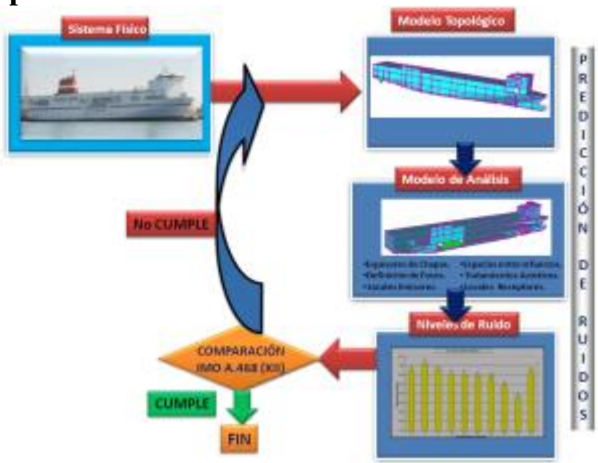

Figure 6. Methodology of the Noise Prediction.

In this chapter the intention is to describe the general methodology for noise level prediction in different locals of the vessel due to the focus of existing noise, using **SEA** method. The first step to define a noise model is to create the topology of the vessel. Once created, the second step is to create the analysis model. In the analysis model, information about the thickness of the plates, space between stiffeners, noise sources definition, local receptor definition and local transmitting and acoustic treatment applied information must be included. With the analysis model created, we can proceed to solve it and as a result expected noise levels in the selected compartments are obtained.

The comparison of theses expected levels with the established limits in the technical specification, will take us either to finish the process or, in the contrary, through a repetitive process to simulate special systems of isolation aimed at reducing noise levels in those compartments which do not accomplish the Specifications. In **Figure 6** a graphic Flow Diagram that corresponds to this methodology is described.

3.3.3. Mathematical Model Description.

SEA method includes two types of existing structure borne noise, the one transmitted by a noise source through the structure, and the one generated in the structure due to airborne noise.

To calculate noise level, the following parameters have been taken in account: **1)** The thickness of the plates and the distance between the reinforcement. **2)** Air noise level and structural noise level of the different equipment. **3)** Isolation drawings in bulkheads and roofs, pavement and sub-pavement. **4)** Plan of the General Disposition of the vessel and situation of focus and locals.

The noise sources, among others, that have been considered to predict noise in the C-509 and C-510 are the following ones: propellers, main engines, gearboxes, auxiliary engines, thrusters, compressors, harbour generator, purifiers, steering gear, HVAC units, fans engine room, garages and technical spaces. In **Figure 7** we can see the Acoustic Model used.

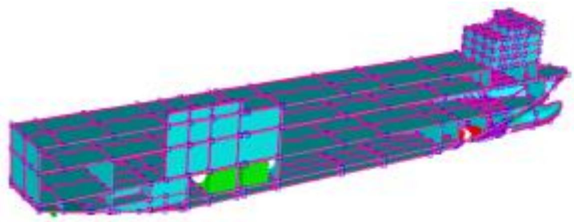

Figure 7. Acoustic Model of the RO-RO's C-509/510.

3.4. Noise Radiated to Harbour Prediction. Answer to the new requirements.

3.4.1. Introduction.

The appearance of a "totally new requirement" in the Specification of C-509/510 of NAVANTIA-Puerto Real from ACCIONA TRANSMEDITERRÁNEA, that the "Exterior noise level should be under 80 dB(A), measured according to ISO 2922/2000 [6] with the vessel in operational harbour condition", has constituted a "novelty".

The reasons for this "new requirement" are two: one is the **Operational**, that answers the need of the Ship-owner to avoid complaints and fines. The second is the **Vision and Sensitivity** from **ACCIONA TRANSMEDITERRÁNEA** in accomplishing the Community Directives related to Evaluation and Management of Ambient Noise in the Harbours, **Directive 2002/49/CE [2]** specifically.

In this point we need to ask ourselves "What did the shipyard do in view of these new requirements?", "Did the shipyard know about the technical and economic incidence of this "added value" that the vessel required?".

3.4.2. Calculation Method applied.

The prediction of the noise generated by the vessel to the harbour has been done counting as a main noise sources the inlets/outlets of the ventilation system that the vessel can have in use during the stay and operations in the harbour.

Figure 8. Noise Radiated to the Harbour Model.

Those inlets/outlets of ventilations had been considered as hemispherical noise sources, in a way that each one generates a sound field of spherical waves. The levels of acoustic power, from each inlets/outlets, have been calculated considering the power and noise pressure of each fan, the ducts dimension and the fan chamber, and its acoustic insulation in case of having it.

As a consequence the accuracy of the obtained results has been constrained by the precision of the data given by the supplier. As a result, with the experience of the authors, this data had to be experimentally proved through factory acceptance tests. In this vessel, the main noise sources of Harbour Radiated Noise are integrated by 58 Ventilation fans from the garages and machinery rooms.

The exhaustion of the main engines and the auxiliary ones have not been considered in this analysis, as the acoustic treatment of this noise source is constrained by the fulfilment of the noise limit in the exterior decks.

With these noise sources characterized, and using the Calculation Model described in **Figure 8** and with the tool developed with **TSI**, called **"NoRaPort"**, we proceeded to estimate, for the different configurations, noise level at the different distances of the vessel. Not only in the quay but also in the main sections of it, where most of the noise sources to the harbour were found. The comparison of these "expected noise levels" at different distances and mainly at 25m of each side of the vessel, and the comparison of the Specified limit of **80 dB(A)**, allowed us to optimize the acoustic design of the different ventilation systems.

3.4.3. Acoustic ORIGINAL Design of Fans. Obtained Results.

The corrections experimentally obtained through FAT tests (Factory Acceptance Tests), as security margins, it was proceeded to do the first prediction of Noise Radiated to Harbour calculation with the **Original Acoustic Design of Fans and Silencers**. In **Figure 9** it is represented the distribution of the resonant weighted pressure level (A), at quay level for port and starboard sides. The represented coloured map was obtained considering 3 distances of calculation, from each of the vessel sides, **1 meter, 25 meters** and **50 meters**. With the arrows graphs we represented the gradient of pressure levels from the quay side according to the obtained results.

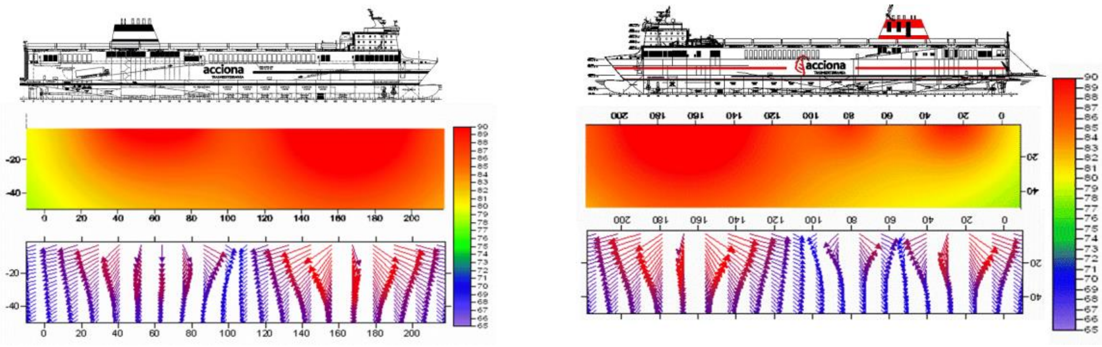

Figure 9. Original Model. Noise Radiated to the Port. Starboard and Port Side.

The analysis of the previously exposed results shows that the expected pressure level **EXCEEDS in +11 dB (A)** the contractual required levels.

For the optional condition analysed (at 1m from the side) out of the Specification, in the same operational conditions as the previous case vessel, the expected noise pressure levels resultant **EXCEEDS in +18 dB(A)** the level of **80 dB(A) at 1 m** from the side.

3.4.4. Acoustic MODIFIED Design of fans. Obtained Results.

Based on the deficient results obtained in the prediction of the noise radiated to the harbour with the **Original Acoustic Fan Design**, the company responsible for the calculation of noise and vibration and exterior noise prediction knowing the needs of the ship-owner and of the Regulations, not mentioned in the Specification but currently in force, recommended the Engineering and the shipyard to do two levels of actions on the silencers: a **First Level** of actions that we will call **Optimization at 25m** and a **Second Level** of action called **Optimization at 1m.** In **Figure 10** are shown the results obtained in the **Optimization at 25m**.

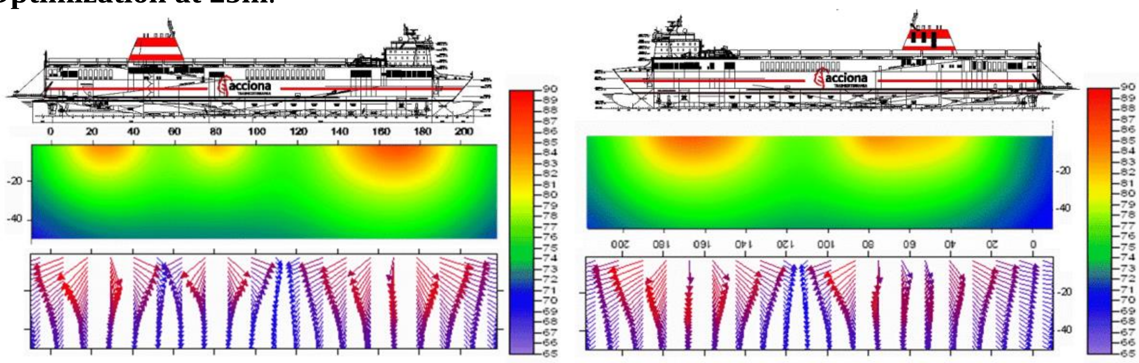

Figure 10. Optimization at 25m. Noise Radiated to Port Distribution. Starboard and Port Side.

As it can be seen in the analysis of them, with the first action, level noise radiated to harbour by the **C-509/510 fulfilled**, for both sides of the vessel, with the 80 dB (A) limits required in the Specification.

4. SEA TEST IN NAVANTIA- PUERTO REAL C-509/510: CORRELATION MODEL/TESTS.

Aimed at verifying the fulfilment of the Contractual Specification in the noise and vibration sections, before delivering each of the **C-509** and **C-510**, **TSI** developed (as the consulting company in charge of the Noise and Vibration Integrated Management), with the previous elaboration of the corresponding protocols accepted and approved by the ship-owner and the shipyard, a program of sea trials that included structural and local noise and vibrations measurement in the main equipment.

The experimental results obtained in this program of Official Tests, which will be summarized in the following sections, will help us to evaluate the **goodness** and **efficiency** of the noise and vibration predictive calculations applied.

4.1. Vibrations Results.

In **Figure 11** there is a summary of the vibration levels obtained in the different areas: machines and working spaces, public spaces and crew & passenger cabins, of the Ro-Ro's vessels **"José María Entrecanales"** and **"Super-Fast Baleares"**, measured during the sea trials when delivery. In those figures and for each type of space, we included the required limits in relation **to ISO Standard 6954/2000 [5]** that its fulfilment was included in the Specification.

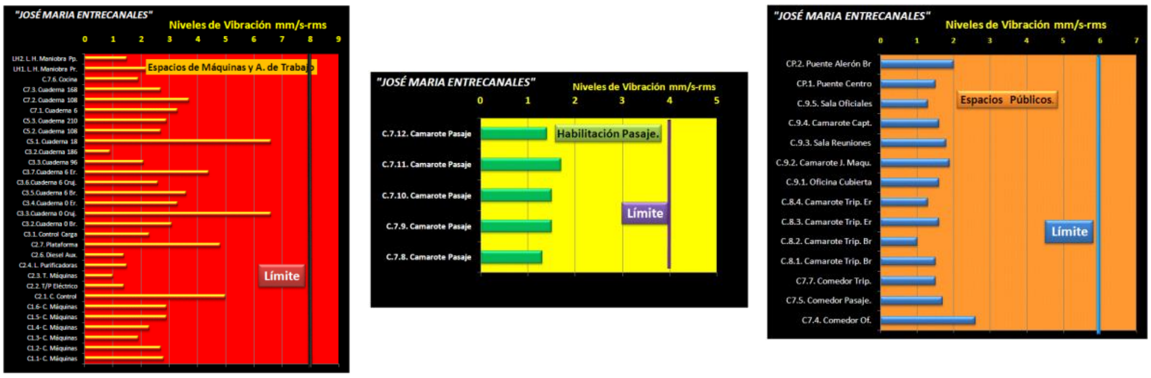

Figure 11. Vibration Levels obtained at different Locations.

From the experimental data examination of vibration levels obtained in the Official Tests of the vessels **"José María Entrecanales" and "Super-Fast Baleares"** we can highlight the following ones:

- In both vessels, vibration levels obtained in the different localization are well below the required limits in the **ISO Standard 6454/2000 [5]**.
- In both vessels the **IMPROVEMENTS** (deviation respect the limits) obtained oscillate between 62% and 71% **below the contractual limits**.
- In a general way, vibration levels obtained in both vesels during the sea trials allow us to confirm that the **"Dynamic design"** in both constructions delivered by **NAVANTIA-Puerto Real**, designed by **SENER** and calculated by the authors, fulfilled satisfactorily the Specification requirements (**ISO 6954/2000 [5]**) even being able to opt for a **Comfort Class 2**.

4.2. Noise Results.

Figure 1. Noise Levels obtained at different Locations.

In **Figure 12** there is a summary of noise levels in different areas: machines and working spaces, public spaces and crew & passenger cabins, of the Ro-Ro's vessels **"José María Entrecanales" and "Super-Fast Baleares"**, measured during the official tests when delivery. In those figures and for each type of space, we included the required limits in relation to **IMO A. 468(XII) Regulation [4]** that its fulfilment was included in the Specification.

From the experimental data examination, of noise levels obtained in the sea trials of the vessels **"José María Entrecanales"** and **"Super-Fast Baleares",** we can also highlight the following ones:

- In both vessels, noise levels obtained in the different localizations are well below the required limits in the **IMO A.468 (XII) Regulation [4]**.
- In both vessels the **IMPROVEMENTS** (deviation respect the limits) obtained oscillate between **-6dB (A) up to -11 dB (A) below contractual limits**.
- In a general way, noise levels obtained in both vessels during the official tests allow us to confirm that the **"Acoustic design"** in both constructions delivered by **NAVANTIA-Puerto Real**, designed by **SENER** and calculated by the authors, fulfilled satisfactorily the Specification requirements **(IMO A 468(XII) [5])** even being able to opt for a **Comfort Class 2 or 3**, in the cases that the insulation rate between cabins and public spaces accomplish the minimum requirements of the Classification Societies.

4.3. Noise Radiated to the Harbour Results.

After the results of the Tests in relation to the measures of Noise Radiated to Harbour by the vessels **"José María Entrecanales"** and **"Super-Fast Baleares" (Figure 13)**, the following remarks are highlighted:

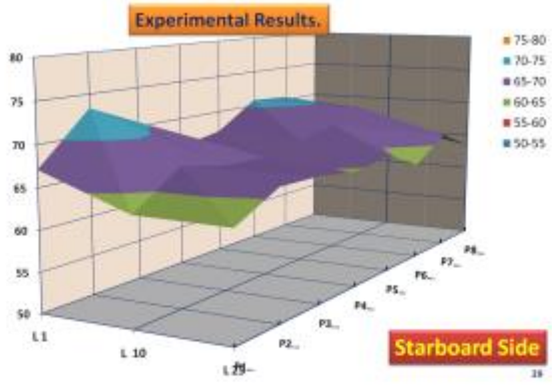

Figure 13. Assessment of the OPTIMIZATION at 1 m.

- In both vessels the Noise Radiated to Harbour level at 25m for each side **ARE WELL BELOW** the **80 dB (A)** limits required in the Specification.
- Also, the **IMPROVEMENTS** (deviation respect the limits) obtained oscillate between -8.5 dB (A) and -15.2 dB (A) for starboard side and between -11.5 dB (A) and -15.6 dB (A) for port side, ARE **WELL BELOW THE CONTRACTUAL LIMITS**.

Noise and Vibration Predictions can be considered **"solid"** tools due to several publications about "Model-Test Correlation" that are endorsed by the experience of the authors in the Silent Vessels and the Oceanographic Vessels, in which they have participated **[10, 11, 12, 13].** With the new requirement of Noise Radiated to Harbour by vessels, it is necessary that the applied "calculation tools" used must be contrasted with the experimental results obtained. **Figure 14** shows the results of this **"Correlation: Exterior Noise Radiated Model/Tests"** for **C-509 at 1m from the side.**

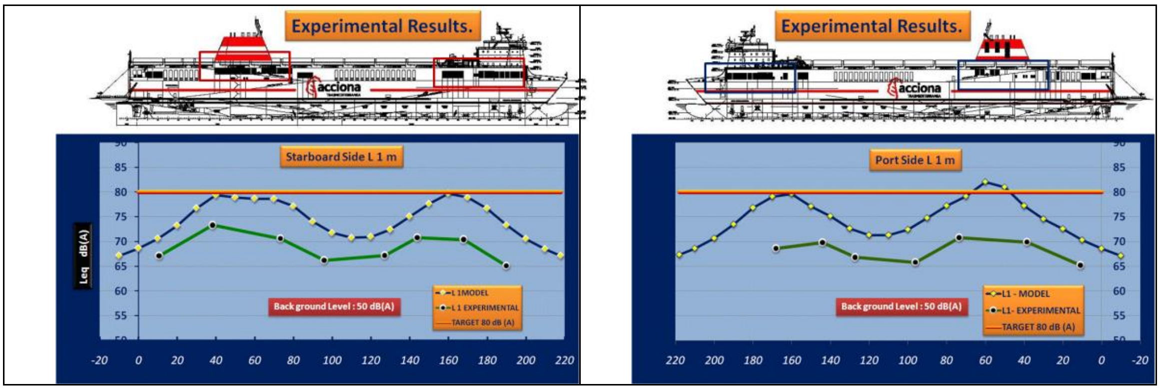

Figure 14. "Correlation: Exterior Noise Radiated Model/Tests" for C-509 at 1m from the side.

Analysing these figures it is possible to confirm that this is a "Solid, consistent and conservative tool to predict Noise Radiated to the Harbour by the vessel" as the expected calculation results are between **+5 and +10 dB (A)** over the values experimentally obtained. Security margins which could be taken as appropriate in noise prediction.

5. CONCLUSIONS: LESSONS LEARNT.

As it is normal in this type of articles, we present Conclusions and "**our professional experiences related to this work"** as **Lessons learnt** that we modestly submit to sea professionals, in order to enrich this with their contributions and comments and, definitely, to be able to improve the quality and competitiveness of our Marine Sector. Some of the most interesting ones, according to our judgement, are detailed in the following items:

- The recent delivery of the RO-RO vessels **"José María Entrecanales"** and **"Super-Fast Baleares"** to **ACCIONA TRANSMEDITERRÁNEA**, designed by **SENER** and built by **NAVANTIA-Puerto Real**, with vibration levels well below (67%) the **ISO 6954/2000 [5]** established limits, noise levels -8 dB (A) below the recommended limits in the **IMO A.468 (XII) [4]**, and finally, noise radiated to harbour levels **within the realm of 15 dB (A) below the 80 dB (A) limit required not only in the Specification but also in the Community Directives, in force, such as 2002/49/EC [2],** achieving an unprecedented fact and becoming an additional technological milestone in the Marine Spanish Sector.
- The **quality of the obtained final product** allows **NAVANTIA-Puerto Real** to reaffirm its position in the selected **"market niche"** of "Silent Vessels", and also, to have a "technically supported reference", in national and international markets where, currently, there is a high demand of these types of vessels.
- The introduction of this Regulatory Framework, due to the fact that it "obliges" the Ship-owners and the managers of the vessel operating companies, in the Specifications is occurring. Well evidenced in the most recent Specifications of all types of vessels in which the author is involved.

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