The new IMO noise code: open letter to the maritime safety committee. A technical opportunity lost: the fishermen and other seamen will continue being deaf. The consequences will be irreversible at a high cost

Abstract

More than thirty (30) years have passed since the appearance of the Code IMO Resolution A.468(XII) until the adoption by Maritime Safety Committee on 30th of November 2012 of the Resolution MSC.337(91). The Code of Noise Levels on board Ships. As mentioned, this new "Code" has been adopted to fulfil the recognized need to establish mandatory noise limits in the different spaces of the ships, and based on the experience gained since the adoption of the Resolution A. 468(XII), with regard to noise control and allowable exposure levels. This new trend is essentially based on the Regulation II-1/3-12 of the International Convention for the Safety of Life at Sea (SOLAS) in 1974 as amendment adopted by the resolution MSC.338(91), concerning protection against noise. The aforementioned regulation II-1/3-12 states that the ships shall be constructed to reduce on board noise and to protect personnel from noise in accordance with the Code of noise on board ships. This new Code will come into force on 1st of July 2014.

In this large period of time, much progress has been made; especially in the topics of noise and vibration on board “all types of ships” as well as the outdoor noise generated by them, which especially affects the environment and the marine life. Connected to this, the new “Green Policy” of the EU for the reduction of the environmental impact of all types of vessels has been generating new Directives that shall affect the Shipbuilding Industry. As a direct consequence, and focusing only on protecting the health of all the seamen on board all types of ships again noise, the corresponding Directives have become local laws of the Member States, mandatory for Ship-owners and Sailors. In parallel and obeying market requirements, the optional Noise and Vibration Comfort Class Notations of the different Classification Societies have been implemented in most of the Passenger Ships, for both Passenger and Crew spaces. Likewise, many sensitized Ship-owners have decided to request stricter noise limits for their commercial ships to attend the local Flag Requirements. Besides, in this demanding scenario, the noise and vibration consultants and the Shipbuilding Industry have had to move forward on providing solutions to fulfill these requirements. Based on real cases of sophisticated and commercial ships, it has been proved that...
the compliance with the strictest requirements, including those concerning the Underwater Radiated Noise (URN) by the ships, is achievable.

In this independent consultant’s opinion, with 37 years of experience solving noise and vibration problems on board ships and industry during all his professional lifetime, the new IMO Noise Code appears as politically or diplomatically correct but technically obsolete, limited, unfair, source of commercial unbalances and, more seriously, not able to fulfill the aim of its definition: to protect personnel again noise on board ships. In order to avoid that these strong words or opinions presented here, with all the respect, could appear as demagogic, in the present report the technical reasons and evidences supporting them are presented.

1. General overview of the regulatory framework

1.1. Introduction

“Noise”, seen as “no desired sound”, has been identified as one of the most polluting factors in the industrialized societies, being the transport, in all its forms: air, land and maritime, one of its main causes. Noise is present in every human activity and is linked, in most of the occasion, with a higher degree of industrial development of these societies.

Calculations have shown that in the United States of America (USA), about 40 millions of people, and between 4 and 5 million in Germany (12-15% of the workforce), are subjected to a level of occupational-noise defined as hazardous by the World Health Organization (WHO, 2001). “Occupational-noise” is assessed in terms of its impact on human well-being, and “ambient noise” is assessed in other scenarios: traffic, sports, music, etc.

On the other hand, even though the noise is associated to any human activity, there are activities characterized by high levels of noise: Mining, transport, agriculture and defence. During the last decades, the widely diffused sensitivity of these developed societies have been forcing the governments and different regulatory agencies to develop drastically new regulatory framework which guarantees their protection against this perturbing factor. During this period, the emergence of the following regulations is noteworthy: IL0- International Labour Organization- Code of practice “Ambient factors in the workplace” (2001) USA – Noise and Vibration Control (2002), directives, which all of them are adopted into national laws of the member states once they are approved.

Overall, the results of these action can be qualified as satisfactory. Nearly all the workforce is protected, without any discrimination, by local laws of Health and Safety at work which guaranty them health monitoring and supervision against every pollutant. And all of this in agreement with the objective criteria defined by International Labour Organization (ILO). The public awareness of these societies by means of education and dissemination has been the driver of this change.

This situation contrasts with the corresponding situation of the developing countries with high growth rates thanks to their natural resources. Even though the amount of available data is limited, there are evidences suggesting the level of occupational-noise in the workplaces is much higher than the recommended ones by the developed nations. The overall level of occupational and ambient noise might be increasing as these industrialization accelerated process do not go with any local regulatory framework for workforce protection.

Although it is not an easy task, in a globalized economy the rights of every person, regardless of its geographical location, to have a “safe workplace” and environmental sustainability are inalienable, principle which is within the principles of the International Labour Organization (ILO). Nothing will be achieved by means of local efforts if they are not framed within a globalized scenario. The education and dissemination of knowledge and experiences collected by the developed countries to the developing ones are essential for this purpose. Especially if we notice these developing countries are in most of the cases the “green lung”.

These opinions are not just the result coming from a strong defence of the environment by the author, but from a strong belief, as an engineer, that one of the main challenges of engineering, whatever kind, is being able to make compatible the society development with decent work conditions, fair trade and sustainable environment.

1.2. Noise in the maritime traffic

As mentioned previously, transport, in all of its forms, has been identified as one of the main contributors to noise pollution. Even though, the land and even air transport are subjected to local regulations, the maritime traffic, since it is global, presents particularities which will be dealt in this paper.

Specifically in maritime traffic, noise and vibration on board vessels have been one of the recurring topics in the Shipbuilding Industry. However, regulation and control of both aspects, noise and vibration on board, have undergone immense changes over time [1]. Thus the situation has undergone drastic changes from the seventies, where the framework was totally ambiguous as can be seen from the expressions used by that time like "The shipyard will do its best to reduce and limit the noise and vibration on board vessels", to the appearance of International Standards, as IMO A. 468/00[2] for noise on board, and ISO 6954[1984][3] for vibration on board. Despite of their “limitations/ exceptions”, result of the “state-of-the-art” by that time, the establishment of limits for the different ship sizes allowed to assess with objective criteria, up to then ambiguous, the noise and vibration on board vessel. That closed the endless work meetings and discussions between shipyards (the vessel does not vibrate and make noise) and ship owners (the vessel vibrates and makes noise), most of which ended thanks to an economic agreement between both parties.

In the nineties, within the booming market of cruiser and passenger vessels, and due to the necessity of ship owners of responding to the more and more demanding market needs, the optional Comfort Class Notations with regard to noise and vibration on board of this kind of vessels appeared. The Classification Societies encouraged these Comfort Class Notations to try to deal this market demand. With the aim to highlight the importance of the technological challenge introduced by these Class notations, it is noteworthy that some Comfort grades established vibration limits of 1-2mm/s-rms, compared with 4mm/s-rms of the ISO standard, and noise limits, especially in accommodation spaces, 15dB(A) lower than the corresponding limit in the Standard.

To face this demand and technological challenge which this implies, the Shipbuilding Industry has respond favorably by means of the most new technologies aimed at complying with this objective. All of this confirms, by the consistency of the facts previously mentioned, that the principle of “Nobody does anything if they are not forced to”, especially if the business goes well, is one of the most important, in the author’s opinion, in the Shipbuilding Industry after the Archimedes principle: in other words, there will be no technological challenges unless the market requires them.

During this period of time, the ISO (vibrations) and IMO (noise) standards, have barely introduced any significant changes and have kept the same limitations/exemptions not easily tenable at the present time. Indeed, in 2000 ISO introduced the revision ISO 6954(2000) [4] which has modifications in the limits of different spaces: 4 mm/s-rms for accommodation and 8 mm/s-rms for machinery spaces as well as changes of the acquisition and post-processing of the signals. This was the result of the progress made about how the low frequencies affect the human body and the development of new techniques.
for signal analysis of the modern equipment. On the contrary, IMO have kept during all of this time its resolution A.468(XII) “Code on Noise Levels On Board Ships”, which came into force on 19th November of 1981 and is going to be upgraded and modified by the Resolution MSC-337(91) “Adoption of the Code on Noise Level On Board Ships” [5] adopted by the Maritime Safety Committee (MSC) on 30th November of 2012 and whose entry into force is foreseen for July 2014.

At the same time, the European Union (EU) within the general framework of its “Green Policy” aimed at reducing the “environmental impact” of all kinds of vessels, is legislating a list of directives as the Directive 2003/10/EC [6], the Directive 2006/87/EC [7] and the recent Directive 2008/56/EC [8], all of them focused on the creation of a new and consistent “Regulatory Framework” to avoid and/or reduce the negative Noise and Vibration effects not only on the ship crew and passengers’ health but also on the environment due to the radiated noise to the air and water.

In the first case, the negative effects of the Noise Radiated to Harbour has now become evident due to the rising number of complaints of the affected people living in the residential areas near harbours and waterways. Regarding the second instance; Underwater Radiated Noise (URN), extensive and detailed research done by the scientific community have enabled the identification of the maritime traffic and its notable growth as the main responsible for the increase of the ambient noise in the oceans, more than 50dB (ref 1µPa) during the last twenty years. Moreover, there is still a heated discussion on this matter about the damage suffered by the marine species due to the ambient noise currently present in the ocean.

Clearly, this comprehensive approach to the vessel impact on both, people’s health and environment, required by the current and forthcoming regulatory framework implies a new challenge for the Shipbuilding Industry. Indeed, and as shown by recent research done in the framework of projects promoted by the EU [9,10,11] the vast majority of projects of civilian vessels of the European fleet, even the newest ones have considered neither Noise Radiated to Harbour nor Underwater Radiated Noise, thus no preventive actions have been taken. Just two exceptions are noteworthy, Navy Vessels and Fishing Research Vessels. The former because of strategic requirements, the latest because of operational requirements of the electronic equipment. This fact is another clear proof the “second shipbuilding principle” (after the Archimedes’ one).

With the aim to radically change this scenario and provide technical consistency to the new Directives, the EU has encouraged different projects within the different Framework Programs, among others, “BESSIT” [9] “SILENV” [10] and “AQUO” [11] aimed all of them at reducing the environmental impact of all kind of vessels. These projects, some of which are already completed, have been funded with tens and tens of millions from European citizens taxes. In these projects the main stakeholders of the sector have been involved; large shipyards, ship owners, research centres, universities and expert consultants as the author.

In this “changing regulatory framework”, after thirty one years (31) of the adoption of the first and unique “Code on Noise Levels On Board Ships”, IMO A.468 Resolution, which have dominated the whole Shipbuilding Industry for the last three decades, a new resolution appears under the name MSC-337(91) “Adoption on the Code on Noise Levels On Board Ships”, which replaces the previous one and whose entry into force is expected for 2014.

In this paper an exhaustive critical analysis of this new Noise Code is done from the author’s perspective, shaped by a large professional career as Noise and Vibration on board vessels specialist along with this Code, or in other words, the fact of having been “fighting” for so many years with its ambiguities and exemptions/limitations.

A first look at it and considering the difficulties to achieve its adoption by consensus, there can be no objection from a diplomatic/political perspective, it is impeccable. However, from a technical point of view, the criteria used to keep the limits of the old code for the vessels between 1,600 gt's and 10,000 gt's and to reduce 5 dB(A) the limits in the accommodation spaces for vessels above 10,000 gt's can be qualified as “technically inconsistent” with the current state-of-the-art and with the aim of protection that the new Code says to have obeying the recommendations of the International Labour Organization (ILO).

Finally, the exemptions established in 1981 by the Resolution IMO A.468(XII) probably because of the knowledge on the matter by those days, still remains in the new Resolution MSC-337(91). That in itself, it is a clear contradiction with the occupational and health safety laws adopted by some Member States of EU result of the Directive 2003/10/EC as well as with universal aims of protection of all workers, without any discrimination, established by the International Labour Association (ILO).

In the author’s opinion, all of these weaknesses make the new Resolution MSC-337(91) “Adoption of the Code on Noise Levels on board Ships” in a minimal agreement, contradictory with the Directives and “universal aims” of protection of all workers against noise and technically obsolete with regard to the current state-of-the-art. Moreover, it will be sooner or later overwhelmed by the reality.

An unquestionable proof for the main stakeholders: Administration, Ship owners and Seafarers, of the assertion “it will be sooner or later overwhelmed by the reality” can be found in the document C080 “Code of practice on noise and vibration in ships”, of the Marine and Coastguard Agency (MCA)[12] which claims that according to British Insurance Association (BIA) the noise induced hearing loss leaders the compensatory claims.

This first quick critical analysis of the new Code would not be more than a subjective assessment. The aim of this paper is to present technical data supporting these appreciations.

2 Noise, its measurement and quantification. The effects on people’s health

With the aim that a non-expert reader can shape their own opinion about the aspects dealt in this paper, overviewing some basic concepts and definitions used has been considering appropriate.

Figure 1: Generation mechanism, propagation and noise reception
2.1. Concepts and definitions

Generally speaking the sound is a physical phenomenon consisting on a mechanical perturbation on the particles of an elastic medium (air, steel, etc.) induced by a vibrating element or an impact, which is perceived, through the human ear, as a sonorous sensation. The Figure 1 shows the generation mechanism and sound perception. The tuning fork (noise source) when it is vibrating perturbs the near air molecules (medium) generating a perturbation in the medium (pressure fluctuations) which results in a pressure wave propagating over the medium reaching the human ear (receptor). This pressure wave while it goes into the auditory chamber, makes vibrate the eardrum membrane, from there goes to middle and inner ear exciting the acoustic nerve endings which finally generates the sonorous sensation. The disorders of this delicate mechanism because of any reason cause incapacitation of the people who suffer from it. The noise is sound which becomes undesired because of its characteristics: amplitude, frequency and duration. Noise, as any wave phenomenon, is characterized by its amplitude: the shock wave of a mine (high), the singing of a bird (low); and by its frequency: a drum (low) or a violin (high).

2.2. Noise measurement and quantification

There is a wide variety of magnitudes and indicators to quantify the noise levels. The most useful ones to assess the noise impact on human health are described by Hollander et al. (2004) [13]. Generally, these indicators are physical magnitudes corrected by people noise sensitivity. This correction varies with the frequency and noise characteristics like intermittency, impulsiveness, etc. The following indicators are usually used for the assessment of the noise levels:

- **Sound pressure level**: It is a measurement of the amplitude of the pressure fluctuation generated by the source/sound. Since the human ear is capable of detecting a wide range of sound levels, from 20. $10^{-6}$ Pa until 200 Pa, the handling in linear scale of it with so wide range is not easy. Because of this the decibel is employed for the quantification of this magnitude. The decibel is defined according to the following expression: $dB = 10 \log \left( \frac{p_2}{p_0} \right)$, where $p_0$ is the reference pressure and equal to the minimum level detected by human ear; 20. $10^{-6}$ Pa. Thus, the human ear can detect and tolerate sounds from 0 dB to 120 dB.

- **Sound level**: The human ear response varies with the frequency, which means that the human ear is not equally sensitive along all frequencies. In order to take into account this phenomenon a spectral sensitivity factor is employed to weight the sound pressure level for each frequency. The units of the A-weighted sound pressure level are dB (A).

**Equivalent sound pressure level**: When sound level varies over time, as it is the case of the noise generated in the workplace, the equivalent sound pressure level is computed for a specific period of time. Consequently, the weighted sound pressure level is averaged for a period of time (T) and it is denoted by $Leq$. The common exposure period usually adopted in the different studies and regulations is eight (8) hours, and this parameter is then denoted by the symbol $Leq_8$ in dB(A).

In the case of seafarers, apart from being a job considered dangerous for organizations like ILO and FAO, the fact that the employees spend twenty four (24) hours a day in their workplace, potentially noisy, must be accounted. The exposure period considered for those cases will be twenty four (24) hours, that is, the magnitude to be obtained will be $Leq_24$.

2.3. The noise effects on human health

It is not possible to summarize in just one paragraph all the bibliography and research about the noise effects on people’s health done by well-known organizations like the WHO, or Occupational Safety and Health Administration (OSHA). We encourage the interested reader to do a quick search on the net with the words Noise Induced Hearing Loss (NIHL) so as to check the scientific solvency of this works by him or herself.

On the contrary, aiming at questioning the suitability of the new Resolution MSC 33(91) “Adoption of the Code on Noise Levels On Board Ships” as a tool capable of protecting the seafarers’ health given its "exemptions and limitations", we have considered appropriate to summarize and draw from the aforementioned bibliography the main conclusions and experiences supporting the doubts about the suitability of this code.

A quick analysis of the epidemiological studies specifically designed to identify the occupational noise effects on people’s health in the workplace, regardless the geographical location where the research were carried out has allowed to conclude that:

“The effects on the human health caused by a certain noise level at work are practically the same, regardless the country or region where the worker is exposed.”

The extrapolation of this conclusion to the maritime scenario establishes that the potential noise effects on human health are the same for any worker who performs its activity in any workplace as the ones shown in the Figure 2.

The overview of the wide bibliography about these topics enables to points out that noise, besides its effects on hearing, has a number of effects on other health aspects. Some of them, such as sleeping deprivation, are important within the context of ambient noise, but they are less likely to be associated to noise at workplace. Other effects caused by noise at workplace such as inconvenience, hypertension, alteration of the human well-being and psychiatric disorders have been described by De Hollander et al. 2004 [13].

The best indicator to quantify the effects of “occupational noise” suffered during a working day on human health is the amount of hearing loss caused by the prolonged exposure to this pollutant. This term is known as Noise Induced Hearing Loss (NIHL). It has been for a long time and it’s still being because a) its direct impact and immediate and irreversible consequences on people’s health, b) the socioeconomic midterm consequences for the countries and c) the economic operational impact on certain groups as the Navies of developed countries as the USA, the subject and cause of a large number of extended scientific researches, of the changing regulatory framework of the last decades and of the implementation of strategies and technology aimed at fighting it.

Indeed, all the scientific researches have shown, by audiometry exams, the first effects of prolonged exposure to excessive noise (high “exposure levels”) are usually a rise of the absolute threshold of hearing, or of the “minimum level of perception”. According to National Institute for Occupational Safety and Health (NIOSH), this change of absolute hearing threshold is defined as a change of $10$ dB for the frequencies, $2,000, 3,000$ and $4,000$ Hz, in both ears. The Noise Induced Hearing Loss is measured comparing the actual hearing threshold for a specific frequency with a value standardized of a normal hearing threshold.
its value is expressed in “hearing loss units” in decibels (dB HL). This change of hearing threshold is the initiator of the hearing loss and it is mainly caused by a high noise exposure at work. As time goes by, this can lead to tinnitus: continuous buzzing in ears and head.

Unfortunately, the Noise Induced Hearing Loss is a progressive phenomenon and the affected workers do not notice the changes until several years later when, irreversibly, a huge change in their hearing threshold has already occurred. Thereby, after several years of exposition to high and dangerous levels of noise, the hearing impairment is initiated with the change of the hearing threshold within the narrow range of frequencies going from 2 kHz to 4 kHz, where the human ear is more sensitive. As hearing impairment is increased, due to continue being subjected to the same noise levels, the hearing capabilities are reduced since the nerves of the inner ear start being affected because of the cell damage and the signal transmission to the brain is then affected. In these cases and caused by the irreversible damage because of the nerve cell destruction, the range of frequencies affected widens to 6 kHz. Since the frequencies generated by the human voice (SIL: Speech Interference Levels) are within the affected range frequency (2 kHz to 6 kHz), the affected worker finally notices their limitations in understanding his co-workers. He is definitively deaf. The degradation time and its severity will directly depend on the noise level and exposure duration the worker has been exposed to.

**Personal consequences:** The personal consequences of this impairment, as the case of a fisherman who attend one of the author’s conferences and claimed to have hearing loss above 70% in both ears, when the worker is forced into retirement are well known: 1) Social isolation; 2) Communication problems with his co-workers and family; 3) Increase of the accidents because of the communication problems and isolation; 4) Anxiety, irritability, self-esteem problems; 5) Medical expenses. Definitely a low quality of life when the worker is retired.

Also, for those affected people who are still working, besides the aforementioned consequences, the following must be pointed out: 6) Deterioration of the capacity to control the working environment, warnings, equipment, instructions; leading to a higher risk of accidents; 7) Reduced productivity; 8) Fewer job opportunities. Indeed, the fact that a medical certificate declaring his or her fitness to perform the work is required and as in this medical certificate the hearing capabilities is a measurable indicator, can limit the work expectations. Thus, having to use hearing aid may not be restrictive to get a job as a waiter, but it is if communication is essential for safety reasons: Deck and machinery officers, officers and sailors of Combat Information Centres, etc.

**National consequences:** Due to the conclusion drawn at the beginning of this paragraph is applicable for all the countries regardless their geographical location, governments must be aware of no-regulation on these matters will end up affecting themselves: High rates of occupational disability, increase of social costs due to increase of the number of accidents, etc. In fact, in a borderless world where communication is so developed, the politicians must be aware of the fact that their citizens are informed about the mechanisms the more developed countries have been forced to establish to protect their workforce. It will be a matter of time that the social pressure forces them to carry out the same change.

**Consequences for Organizations/Companies:** According to what is contained in the document of the Marine Coastguard Agency (MCA) to adapt the Directive 2003/10/EC [6] to marine sector, “Noise Induced Hearing Loss is one of the main causes of the compensatory claims according to the British Association of insurance Companies”. Besides practically all the developed countries having advanced social protection systems, a “hearing impairment” of any worker is a prescribed disease cause of worker retirement and its salary will be paid thanks to taxes of all the citizens and companies.

It is worth mentioning the group of 107,000 US-navy sailors living and working in US-Navy vessels, for who the noise is something more in their daily life. In a recent research of the Centre of Naval Analyses (CNA), “Statistical Analysis of Hearing Loss among Navy Personnel” in February of 2005 by Geoffrey B. Shaw and Robert P. Trotz, has found the direct correlation between long-term destinies in surface vessels with an increase of hearing loss. The Veteran Administration (VA) asserts that the associated costs of the hearing impairments have reached more than 6 billion of dollars between 1968 and 2006. Besides, wasting time, productivity reduction, loss of workforce and highly trained personnel, military disability settlements and retraining must be added to all of that. Considering all these consequences the US-Navy, under the heading “Buy Quiet” put in place a strategy to change this trend. Noise control is essential to protect the detachment, the mission success and the retention of the personnel.

Because of the aforementioned reasons the fight against this pollutant; noise, shall be comprehensive, around the world and with zero-tolerance. This can be achieved firstly by the implementation of mechanisms of cooperation between the developed countries, which have already suffered from the consequences of the no-protection, with the developing countries. The guidelines of organizations like International劳工 Organization (ILO) about workforce protection from noise are essential. Anyway, deeper specifications about noise exposure limits and penalties for no-compliance are missing in these guidelines. One must be aware that the “ambiguities”, “exemptions” and “limitations” end up causing vulnerability, detracting any try of regulation. A clear example of what shall be done to protect workforce against noise is the transposition of the Directive 2003/10/EC [6] for all kind of vessels performed by the Maritime Coastguard Agency of the British government [12].

Finally, it is important to highlight that the Shipbuilding Industry, during these last 31 years, has shown amply its technological capacity to respond successfully to the challenge of building ships, of all kinds, what do not present a health risk for all the seafarers working on them. The comfort levels, with regard to noise, achieved in the cruiser vessels, leisure vessels and yachts, or in specific vessels as the fishing research vessels, or the merchant vessels whose sensitivity ship owners have imposed to comply with strict noise requirements, are a clear proof that there is no technical limitation that makes impossible to achieve low level of noise in all kinds of vessels, regardless of their dimensions and size. Not taking these actions is savings for a few people today and will lead to high costs for those affected as well as to the countries and the rest of the citizens.

3 The “new” and “old” code of noise on board vessels. Technical aspects. Comparative analysis

3.1 Introduction

Once the reader has a general overview of: Current Regulatory Framework on noise, the universality of the guidelines provided by the International Organizations, the consequences of the worker vulnerability against this pollutant and the basic concepts about noise, it is time to examine and analyse the new resolution MSC-337(91) “Adoption of the Code on Noise Level On Board Ships”. Throughout the text we refer to this code as “the new resolution” or “new code”. This new resolution replaces the resolution A.468(XII) “Code on Noise Levels On Board Vessels”, currently in force. We will refer to this code as the “old code” or “old resolution”.

Aiming at allowing the reader to shape their own opinion in this paragraph a comparative about the most important aspects of both resolutions has been carried out, starting with technical aspects and finishing with the formal ones. At the end of each paragraph the author’s comments are summarized.
3.2 Comparison between Noise Limits in the different ship spaces

The first difference between both resolutions: A.468(XII) and MSC.337(91) is found in the division of vessels according to ship size. Whereas the first one is applicable for vessels whose tonnage is equal or larger than 1,600 gt’s, there are two sub-groups in the second one: Vessels whose tonnage is from 1600 gt’s to 10,000 gt’s and another group for those vessels whose tonnage is above 10,000 gt’s. According to that, Noise Limits of both Codes for the different vessel spaces and their denominations have been shown in the table of the attached Figure 3.

From the analysis of the Figure 3, we can see that the changes introduced by the new Resolution MSC.337(91) concerning Noise Limit Levels in terms of A-weighted Sound Pressure Levels are only in the following points:

- There are now two sub-groups according to the vessel size. The first one from 1600 to 10000 GT’s, and the second one for vessels above 10000 GT’s.
- The Noise Limits of the different spaces has not been modified for the first group with respect to the A.468(XII) resolution. Therefore the old Code keeps in force in these vessels, which means that the seafarers of these vessels are under the same level of protection as 31 years ago. No detailed explanation about why these limits are still applicable has been found in the new Code.
- However, some improvements have been introduced in the noise limits for the vessels above 10,000 gt’s. They have been confined to a reduction of 5 dBA in the following spaces: Cabins and hospitals, mess rooms, recreation rooms and offices, mainly.

3.3 Comparative acoustic isolations of Accommodation Spaces

With the aim to guarantee privacy, mainly in the cabins, as well as to make possible rest and pleasure activities when other activities, like music, conversation and cargo movement operations are carried out in adjacent spaces, both resolutions recommend paying special attention to the acoustic isolation between these spaces. The airborne noise acoustic isolation properties of the bulkheads and decks, of the accommodation spaces had to be in accordance with standard ISO R-717 (1:1996) according to the A.468(XII) Resolution. The new Resolution MSC.337(91) requires the properties of acoustic isolation to comply with the ones established by ISO 818.1:1996 under the amendment (1-2006) part 1.

The table of Figure 4 shows the limits defined by both resolutions for the Weighted Airborne Noise Acoustic Insulation (Rw).

Both Regulations: “New” and “Old” Regulation provide this index shall be obtained experimentally by laboratory tests according to ISO R-140 Part III (Old Code) or ISO-101440-2:2010 (New Code).

The following comments have been considered appropriate to point out about this “index”:

- In the paragraph 6.3, Erection of materials, the Resolution A.468(XII) provided ambiguously that “care should be taken in the erection of materials in the construction of accommodation spaces to ensure the greatest practicable extent that the attenuation values specified in 6.2 are not significantly impaired”.
- On the contrary, the Resolution MSC.337(91), also in its paragraph 6.3, although it keeps the same ambiguous recommendation with regard to the care “in the erection of materials in the construction of accommodation spaces”, goes a little bit further, even though it is still ambiguous, providing that “during sea trial testing, if the erection of materials is in doubt then measurements should be taken on board ships for a representative selection of each type of partition, floors, doors, etc.” taking as acceptable deviation of 3 dB to the values specified in paragraph 6.2.1 of this code. And it finishes that delegating the responsibility of deciding the validity of the results of these experimental tests to the Administration.

Therefore, from this comparative analysis, and even though the new Code admits the problem concerning the acoustic isolation properties of the materials and the erection of the accommodation spaces, we can infer that this code does not dare to solve this problem resolutely. Likewise, delegating this matter to the Administration is, as the experience says, the same as not finding a final solution to the problem. Nothing or almost nothing will be done to solve it. Therefore, the ambiguity of paragraph 6.3 of the Resolution A.468(XII) has been replaced for another “more sophisticated” ambiguity causing no guaranty to solve the problem which, paradoxically, is recognized.

Indeed, the experiences collected during the last three decades concerning the matter about the Airborne Noise Acoustic Isolation Index between accommodations spaces point out the following facts:

1. Throughout his professional life and after performing Noise and Vibration
measurements required by the contract specifications on more than 500 vessels, the author has only been involved in one test to check experimentally the “theoretical laboratory values” of the Airborne Noise Acoustic Isolation Index of the employed materials.

2. Differences between the theoretical values of the materials employed and the Acoustic Isolation Index experimentally measured are around 5-7 dB depending on the quality of the assembling. Moreover for cabin doors, deviation values have reached up to 10 dB.

3. According to the aforementioned second principle ("Nobody does not do anything if they are not forced to"), why is a shipyard going to offer to install materials with 38dB of Rw, if it has laboratory tested materials according to what is required by IMO? Especially knowing the fact that no experimental verification for this indicator is required.

4. As a result of such ambiguity we can easily suppose that most of the vessel fulfilling IMO A.668(XIII), their Acoustic Isolation Indexes could be under the required values. In fact, many actions had to be taken to solve problems of this kind because of ship crew claims.

5. Non-compliances with regard to this matter will continue if similar ambiguity is kept in the new resolution MSC.337(91) applicable for new vessels after July 2014. In fact, the experiences of some Classification Societies could be included in the new Code. Some of the Classification Societies, as Bureau Veritas, require the experimental verification, performed by themselves, of the Acoustic Isolation Index for the achievement of the Comfort Class Notation.

6. Consequently, according to these new and sophisticated ambiguities like, “during sea trial testing, if the erection of materials is in doubt then measurements should be taken on board ships” according to what the Administration requires, one can expect no big changes about this matter. In fact, Who is going to call into question the quality of materials and assembly? Under which criteria if he does not have experimental tests to evaluate it? Does anybody even know any administration having intervened in this matter during the 31 years in which the old Code has been in force? The author, during his 37 years of experience, has not ever seen anything like that in his country. The main tasks of the Administration are far out from the matter of noise.

7. Therefore, the actual new scenario foreseen is as follows: On the one hand there are the ship owners who are sensitive with acoustic protection of their seafarers and, in order to avoid high extra-costs because of the replacement of the material of the accommodation spaces, will require contractually the performance of experimental test certifying both, the quality of the employed materials and their assembly in the accommodation spaces. On the other hand, there are ship-owners who, maybe because of ignorance, will only require the fulfilment of the new Resolution MSC.337(91). Due to the practical reasons mentioned in the previous point 3, and according to the “aforementioned second principle”, the shipyard will do no more than they are asked to. The controversy will be certainly caused by this “ambiguity” in the same way as in the seventies, when well defined Noise and Vibration limits were not available. In view of the likely passivity of the Administration, if the ship owner doubts about the quality of the materials or their installation, he shall obtain experimental data supporting this doubt. This kind of conflict is likely to be solved by means of the corresponding economical penalty or agreement on the final cost of the vessel.

8. Both, ship owners of the second type and shipyards considering this a way to save money must be aware of the fact that the expected savings because of proceeding in this way may lead to loss of 100 and 1000 times these “expected savings”: Indeed, a change of the materials already mounted as well as the hard task of having to remove all the accommodation sometimes implies delays of more than 2 months and sometimes it is even technically infeasible. In fact, there were cases that a Comfort Class grade 3 had to degrade to grade 2 because of error of this kind causing the corresponding penalty to the shipyard, the accommodation supplier and even to the ship-owner who had to accept a vessel whose comfort grade is under which he wanted to acquire. In other words, everybody loses.

3.4. Noise exposure level comparatives

Noise, as previously mentioned, is a pollutant for people’s health: The grade of affection and its progress over time depend on the two following points: Noise level under which the person is exposed and the duration or exposition time to it.

According to chapter 5 of both Resolutions, the old and the new one, if the Level Noise Limits specified in Chapter 4, are fulfilled in the different accommodation spaces (Table 3) the 24 hour equivalent continuous sound level shall not exceed 80 dB(A). This indicator is expressed as Leg (24h) <80 dB(A). Unlike the old Code, the new Resolution MSC.337(91) recommends (should be), not requires experimental verification during the official sea trials of the fulfilment of this criterion for all the personnel of the ship crew, according to the method described in its Section 3.7.

Both regulations keep the requirement of using ear protectors or reducing the exposure time for those spaces in which the noise levels exceed 85 dB(A). The new regulation also specifies the attenuation of these ear protectors, which shall be at least 25 dB(A), whereas the old one did not have any specific requirement for these devices.

Moreover, both resolutions keep identical criteria concerning the exposure limits to high level noise. They lay down that seafarers cannot be subjected to noise level exceeding the limits specified in Figure 5 according to exposure time. According to that the following areas are defined:

**Zone E. Maximum exposure without protection:** For exposures of less than 8 hours, seafarers without ear protection should not be exposed to noise levels exceeding 85 dB(A). When seafarers remain for more than 8 hours in the spaces with a high noise level, an Leg (24h) of 80 dB(A) should not be exceeded. Consequently, for at least a third of each 24 hours each seafarer should be subjected to an environment with a noise level not exceeding 75 dB(A).

**Zone A. Maximum exposure with protection:** No seafarer even wearing ear protectors should be exposed to levels exceeding 120 dB(A) or to an Leg (24h) exceeding 105 dB(A). Zone D. Daily exposure: if seafarers routinely work (daily exposed) in spaces with noise levels within zone D, ear protectors should be worn and hearing conservation programme may be considered. The only difference introduced by the new Resolution MSC.337(91) is the specification of the required ear protectors which shall have an attenuation of at least 25 dB(A), as well as the establishment of an additional “Risk Analysis” programme.

**Zone B. Occasional exposure:** For this zone, both resolutions the old and the new one only allow occasional exposure. Although the old regulation recommends ear protectors, unless the exposure is no longer than 10 minutes, the new regulation requires the use of ear protectors whose attenuation is between 25 and 35 dB(A).

**Zone C. Occasional exposure:** In zone C only occasional exposures should be allowed and
ear muffs or plugs should be required. The “new regulation” specifies a bit more and it requires this acoustic protection should have an attenuation of more than 25 dB(A). Finally, regarding the level of noise exposure of seafarers, the old regulation recommended to follow a Risk Analysis Programme and the new one to follow a Hearing Conservation Programme. In both regulations the following points are essential concerning this conservation programmes:

1. Initial and periodic audiometric tests administered by a trained and appropriately qualified person, “to the satisfaction of the Administration”. This sentence is underlined to assess its consistency later on.
2. Instruction of exposed persons on the hazards of high and long duration noise exposures and on the proper use of ear protectors.
4. Periodic analysis of records and hearing acuity of individual with high hearing loss.

As summary of the comparative analysis of the “Exposure Levels” specified by both resolutions, the following observations are highlighted:

A. Both resolutions keep the same requirement about unprotected seafarers should not be exposed to 24 hour equivalent continuous sound level greater than 80 dB(A).

B. The new resolution: MSC.337(91), unlike the old one, A. 468(XII), specifies the minimum attenuation required on the ear protectors, fixing a value of 25 dB(A) at least for the “Zone A. Daily Exposure” and between 25 and 35 dB(A) for the Zone B. Occasional exposure.

Consequently, except for the last amendments, there have not been any significant changes with regard to “exposure levels” between the Resolution A. 468(XII), proclaimed 31 years ago, and the new Resolution MSC.337(91) which comes into force in 2014.

After an exhaustive reading of both resolutions, the following comments and remarks are made:

- Clearly, the analysis of the database of the initial and periodic audiometric test records provided by the Resolution A. 468(XII) thirty one years ago, and “administered by a trained and appropriately qualified person, to the satisfaction of the Administration” shall be the scientific document supporting the criterion of keeping the same exposure level of 80 dB(A) during 24 hours, in the new Resolution MSC.337(91). An statistical analysis of the data coming from the different Administrations could have finally guaranteed there is no any hearing loss if the seafarers are exposed to a 24 hour equivalent noise of 80 dB(A). Sadly, none of this can be found by the author after an extensive research.
- Moreover, if this criterion, set 31 years ago, of the 24 hour equivalent continuous sound level limit, is technically consistent, as it is proved by the fact that the new MSC.337(91) keeps it, one may ask why are the noise limits of certain accommodation spaces reduced by 5 dB(A) in the new code for vessels of more than 1000GT’s? It looks like inconsistent considering, as it is indicated in both resolutions, “The noise level limits are designed to ensure that, if they are complied with, seafarers will not be exposed to an Leq (24) exceeding 80 dB(A).”
- Taking into account seafarers live and work for 24 hours a day on board vessels, the exposure levels clearly have to be fixed for those 24 hours. In order to be able to compare the exposure level of the seafarers with the corresponding of any other worker ashore whose workday is of 8 hours, the exposure level has been adapted to the corresponding level of eight (8) hours set by the different regulations. By means of the equivalent energy law, a 24 hour equivalent sound level of 80 dB(A) corresponds to an 8 hour equivalent sound level of 85 dB(A).
- Firstly, this 8 hour equivalent sound level of 85 dB(A) is much higher than the average for any one share work. Secondly, and according to the recommendations of the Directive 2003/10/EC, specific training, means of protection and health monitoring of the workers are required if they will be exposed to an equivalent sound level between 80 dB(A) and 85 dB(A).
- Finally, the National Institute for Occupational Safety and Health (NIOSH) have obtained from the available data that 15% of the workers subject to 8 hour equivalent sound level of 85dB(A) will develop hearing loss. According to that organization, the material hearing impairment is defined as average hearing thresholds exceeding 25 dB HL at 1,000, 2,000, 3,000 and 4,000 Hz. In the United States, the Occupational Safety and Health Administration, by means of the Hearing Conservation Amendment of the Noise Standard, requires the employer to obtain the baseline audiogram of all the workers exposed to 8 hour equivalent sound level of 85dB(A). The yearly audiogram of each worker is compared to the corresponding baseline audiogram to identify the hearing changes which may be caused by this exposure to noise.
- Looking at this state-of-the-art, it is understandable the worries of the author about the lack of statistical or technical data supporting the maintenance of the 24 hour equivalent sound level limit of 80 dB(A) defined 31 years ago by the Resolution IMO. A. 468(XII). This lack is even more remarkable if we take into account that the old code established initial and periodic audiometric tests administered by a trained and appropriately qualified person, to the satisfaction of the Administration. Perhaps, these Administrations may answer these questions.
- In the maritime sector, the fact that the seafarers may be the ones who force regulatory changes about the 24 equivalent sound level limit due to the amount of information they are getting thanks to the requirements of the Directives and local regulations cannot be discarded. A fact that confirms this assertion is the number of claims because of hearing loss indicated by the Association of British Insurers [12].

3.5. Operating conditions during Noise Level Measurements

Finally and from a technical point of view, regarding the vessel Operating Conditions during the noise level measurements, the Resolution MSC.337(91) has solved the ambiguities existing in the A. 468(XII) resolution.

So, whereas the old code set that during the measurements in sailing condition the main machinery should run at normal design service shaft speed, the new one sets that noise measurements shall be taken at normal service speed and, unless otherwise addressed, no less than 80% of the maximum continuous rating (MCR).

Likewise, for the dynamic positioning condition, the IMO Resolution A. 468(XII), considering that the vessel may be subject to high noise level, recommended to perform measurements at positions around thrusters, stabilizers, etc. However neither it is clear if these levels should be compared with the maximum acceptable sound pressure levels nor the load conditions of the thrusters are specified. In the new code, if the dynamic positioning is intended for continuous operation, the measurements at the contiguous machinery and accommodation spaces and duty stations should be done to ensure compliance with the fixed noise limits.

Finally, for those cases in which the system is intended for short temporary use, only for instance during port manoeuvres, measurements are only relevant for ensuring compliance with limits of noise exposure.

No significance differences about the measurements at operating conditions in port have been found between both resolutions. In the chapter of “Measurements” of both resolutions, chapter 2 of the Resolution A. 468(XII) and 3 of the MSC.337(91), some modifications have been identified, which are summarized as follows: Measurement of the C-weighted equivalent continuous sound level Leq(T) and the C-weighted peak sound level LPpeak shall be made in spaces where LLeq(T)
exceeds 85dB(A) for the purpose of determining appropriate hearing protection according to the HML-method, described in chapter 7 and appendix 2.

Finally, in the appendix 3 “Suggested Methods of Attenuating Noise”, the new code MSC-337(91) recommends that in the design phase of new ships, the designer/yard predict by calculations, qualified assessments or the like, the expected noise levels in areas of the ships likely to have noise levels over acceptable levels. Therefore, feebleness is observed with regard to the application of Noise Control Methods that have been shown their efficiency and suitability for the past 31 years.

4 The “new” and “old” code of noise levels on board ships. Formal aspects and exemptions

4.1. Introduction

Once the analysis of the most significant technical aspects of both resolutions is done, in this paragraph we will focus on the “formal aspects and exemptions”. In the author’s opinion, they are both more confusing, ambiguous and contradictory than expected for any Standard, Directive or Regulation aimed at complying with the basic aim of seafarer protection against noise on board vessels, also dangerous pollutant with logged effects and in some cases with irreversible worker health consequences as it is recognized by countless International Bodies. Since, in terms of both concepts, the new resolution MSC.337(91) could be considered as an extension of the old code A.468(XIII) Resolution, the following analysis will focus only on the exam of the aforementioned aspects corresponding to the Resolution MSC-337(91). Firstly a description of these formal aspects and exemptions will be made to assess them afterwards.

4.2. Formal aspects

In the first page of the new Resolution, and as a justification of the adoption of the Code on Noise Levels On Board Ships, the following paragraphs are highlighted:

- “RECOGNIZING the need to establish mandatory noise level limits for machinery spaces, control rooms, workshops, accommodation and other spaces on board ships, taking into account experience gained with regard to noise control and allowable exposure levels since the adoption of resolution A.468(XIII).”
- NOTING regulation II-1/3-12 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended (hereinafter referred to as “the Convention”), adopted by resolution MSC.338(91), concerning protection against noise.
- NOTING ALSO that the aforementioned regulation II-1/3-12 provides that ships shall be constructed to reduce on board noise and to protect personnel from noise in accordance with the Code on noise levels on board ships (hereinafter referred to as “the Code”).
- A first look at these justification points of the adoption of the Code on Noise Level On Board Ships gives the reader hope about the strength and conviction of the following aspects:
  - Necessity of forcing to comply with Noise Level Limits in the different ship spaces as well as, setting noise exposure limits which, complying the Resolution II-1/3-12 of SOLAS, guarantees the seafarer protection against noise.
  - Such belief is strengthening when the code, referring to the Regulation II-1/3-12, is strong about that the vessel shall be constructed to reduce on board noise.

Any hope about the regulatory strength of the new Resolution, vital in the fight and reduction of the noise on board ships, disappear when in the next page, Chapter 1, paragraph 1.1.3, under the General paragraph, the following can be read:

“Although this Code is legally treated as a mandatory instrument under the SOLAS Convention, the following provisions of this Code remain recommendatory, options for compliance, or informative in nature”.

And the situation is absolutely confusing when the new code refers to the provisions of this code as “recommendatory”, “optional” for compliance and “informative in nature”. These provisions are the following:

- The paragraphs 1.3.2 and 1.3.3 concerning the vessel size to which this new code is applicable. Paragraphs that will be analysed later on.
- The paragraphs 3.4.2 and 3.4.3, concerning the noise level measurements in port conditions, when the machinery, as the ship cargo handling induced noise are expected to produce high level of noise in the accommodation spaces.
- The Chapter 5: “Noise Exposure Limits”, concerning the “defined limits” of the “exposure noise levels” to minimize the seafarer health risks, in particular the hearing loss over time as a consequence of the high noise exposure levels.
- The paragraph 6.3 concerning the airborne acoustical isolation of the employed materials as well as their erection.
- Finally, in the annexes 2, 3 and 4 concerning “Guidance on the inclusion of noise issues in safety management systems”, “Suggested methods of attenuating noise” and “Simplified procedure for determining noise exposure”.

The fact that the code remains recommendatory can be understood for the aforementioned annexes 2 “Suggested methods of attenuating noise” as they are general guidelines for this purpose. However, the big inconsistency with the targets initially pursued is found in the fact that the code also remains recommendatory and optional in Chapter 5 of the new regulation MSC-337(91), where the noise exposure limits are defined for the different sound pressure levels in the different work spaces and rest of the ship crew.

Moreover, the fact that the code remain recommendatory is even more striking when, as shown by several international bodies and agencies, the risk of suffering from hearing loss is best indicated by this indicator.

This fact is not either understood when the paragraph 1.2 “Purpose” says “the purpose of the Code is to limit noise levels and to reduce seafarers exposure to noise to achieve, among other aspects, the following:

- Protect the seafarer from excessive noise levels which may give rise to a noise-induced hearing loss and,
- Provide the seafarer with an acceptable degree of comfort in rest, recreation and other spaces and also provide conditions for recuperation from the effects of exposure to high noise levels”.

And the scenario is getting even more confusing, having in mind the importance, as it is recognized by the Code, of the noise level limits to ensure compliance with the 24 hour equivalent continuous noise exposure limits of 80 dB(A), when in paragraph 4.1 the following about definition of limits can be read:

“The limits specified in this section shall be regarded as maximum levels and not as desirable levels. Where reasonably practicable, it is desirable for the noise level to be lower than the maximum levels specified”.

4.3. Exemptions

Regarding the exemptions, the new Resolution MSC.337(91) and the old code A.468(XIII) have the same exemptions concerning the following aspects: 1) Vessel tonnage to which the code is applicable and 2) Type of vessels.

4.3.1. Vessel tonnage

As the old code, the new resolution sets the following exemption regarding the vessel tonnage:
1. “The code applies to new ships of a gross tonnage of 1600 and above.”
2. “The specific provisions relating to potentially hazardous noise levels, mitigation, and personal protective gear contained in the code may be applied to existing ships of a gross tonnage of 1600 and above, as far as reasonable and practical, to the satisfaction of the Administration”.
3. “The code may be applied to new ships of gross tonnage of less than 1600 as far as reasonable and practical, to the satisfaction of the Administration”.

4.3.2. Type of vessels

To the generic sample made up by the seafarers, who, according to the initial purposes, both codes were aimed at, another reduction will be applied, apart from the previous one concerning the vessel tonnage. This reduction is caused by the non-applicability of the code for certain kinds of vessels. So, both resolutions presuppose that the code, seen as a tool for the protection of the seafarers against noise, is not applicable to the following kind of vessels: 1) dynamically supported crafts, 2) high-speed crafts, 3) fishing vessels, 4) pipe-laying barges, 5) crane barges, 6) mobile offshore drilling units, 7) pleasure yachts not engaged in trade, 8) ships of war and troopship, 9) ships not propelled by mechanical means, 10) pile driving vessels and 11) dredgers.

Everything would have been much simpler if both codes had only said that the Code on Noise On Board Ships and the tools of protection obtained from their application is limited to merchant vessels whose tonnage is 1600GT’s or above and exclusively for the seafarers who live and work on them.

5. Comments, analysis and assessment of the formal aspects and exemptions of the new code on noise on board ships

Once the formal aspects and exemptions have been presented, analysis and comments about them are detailed below.

5.1. Temporary Obsolescence

There are 31 years of difference between the adoption of the Resolution IMO A. 468(VII) and the resolution of the Resolution MSC-33(7)) by the Maritime Security Committee on 30th November of 2012. During all these years, as can be seen in the specialized bibliography, there have been a lot of technical and scientific progress on knowing the risks because of the noise exposure as well as many technical improvements applicable for noise control and reduction. Therefore it is difficult to understand that, after so long period of time and so many technological improvements on this field, the new Code has very few modifications and the same exemptions included in the old Resolution. Therefore, the new Resolution is obsolete even before its entry into force not only with regard to the current Directives and Regulations on this field, but also with regard to the current state-of-the-art in Shipbuilding Industry to prevent and control high noise levels in all kinds of vessels.

This short scope as well as their premature obsolescence immediately catches the attention when we compare it with the strength and quick response of this body when regulations are required to avoid accidents such as the one shown in Figure 6. Unlike the consequences of the high noise level exposure which, as seen before, has silent delayed effects these kind of accidents have immediate media effects.

5.2. Comments about the formal aspects. Regulatory Obsolescence

The entry into force of the resolution MSC-33(91) is foreseen for the next 1st July of 2014, that is, 11 years later than the entry into force of the Directive 2003/10/EC. “On the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), which took place on 15th February of 2003. Its seventeenth article says that the Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with the directive before 15th February of 2006. Finally, the same article also says that whenever necessary Member States have an additional period of 5 years from 15th February of 2006, that is to say a total of eight years to implement the provisions of Article 7 in which the maximum noise exposure limits are defined with regard to the personnel on board sea going vessels without any restriction with regard to tonnage of type of vessel.

As a first regulatory contradiction with the current regulatory framework in Europe (Directive 2003/10/EC we have the exemptions that the new regulation includes. There is no need to be an expert on law to realize that these regulations are contradicting each other with regard to this matter. Indeed, the protection of seafarers’ health against high noise levels is limited to the ones on board of the new merchant vessels which, because of age and tonnage, the new code is applicable to.

Secondly, the delegation to the Administration of the application of the Code on Noise Level on Board Ships to the existing vessels, which for tonnage are within the field of application, and to the other vessels whose tonnage is below 1600GT’s will lead to the following situation: First, we have those Administrations of the Member States of the European Union which, as they are subject to the Directive 2003/10/EC, will be forced to the rigorous application of the provisions without any kind of discrimination with regard to vessel tonnage or type and even age. Very difficult situation for these Administrations, but which shall be solved. On the other hand there are the Administrations of those countries which endorsed the resolution but they still lack the specific regulations adapted to the maritime sector. In this case no actions are expected, as shown since the adoption of the old Code.

So, we are in a scenario where workers will be protected differently from noise because of difference in scope and requirements depending on the country. Therefore, we have from the enforceability of the fulfillment with the noise exposure limits of the European Countries for any vessel to the recommendatory character which the new Resolution proposes only and exclusively to the vessel whose tonnage and type are what is included in the new Code. Such thing is, in the author’s opinion, a clear contradiction with the provisions of the ILO with regard to the improvement of the working conditions of all workers without limitation and discrimination.

Finally we encourage the interested reader to look at the “Merchant Shipping and Fishing Vessel (Control of Noise at work) Regulation 2007 (SI 2007/3075) of the MCA [12] as implementation of the Directive 2003/10/EC Physical Agents (Noise) so they can shape their own opinion about this topic. Below, some significance aspects of this regulation are detailed. Throughout the text we will refer to it as “Noise Regulation 2007”.

• Firstly, with the aim to avoid any regulatory contradiction, the Noise Regulation 2007 intends to extend the provisions of the
Directive 2003/10/EC to the seafarers, without any exemption and/or limitation.

- Recognizing that up to its entry into force (6th of April of 2011), except from the existence of general requirements to protect the health and safety, there was no any regulation protecting the workers of the maritime sector (without exceptions) from the health risks caused by the noise exposure at work, the new Noise Regulation 2007, establishes, among other things, provisions for:
  - Actions, daily and weekly Noise Exposure Limits.
  - Risk assessment.
  - When no reasonable and feasible, elimination and reduction of the noise exposure.
  - Prohibition of exceeding the limit values.
  - General provisions. Individual ear protectors, information, training of the workers exposed to noise, health monitoring and consultation to the workers.

The main affected by the Noise Regulation 2007 are operators of vessels, fishing ships and other kinds of crafts, including yachts, etc. what have employees and they are registered in the UK. Regardless the limitation on the applicability because the geographical scope is limited to UK, this regulation, in the author’s opinion is a clear example of zero tolerance with regard to the harmful effects on seafarer’s health caused by noise. In addition, if it was not clear enough its zero tolerance, in other paragraph this regulation provides the following:

“As the regulation is aimed at improving the health and safety of the workers on board vessels of the United Kingdom and fishing vessels, the rules have penalties for incompliance”.

This is perfectly consistent with the universal principles of ILO. Thus, the Noise Regulation 2007 is applicable to every registered vessel in UK, private or public, which employs workers regardless of their nationality, as it is aware of the fact that the existence of exemptions leads to a lack of protection of the workers against noise. Finally, this regulation is also applicable to vessels what are in UK territorial waters even though they are not registered in UK.

5.3. Comments on the exemptions because of tonnage. Technical obsolescence I

From a technical point of view, the following comments about the exemptions because of tonnage applicable in the old and new code are pointed out:

- None of these resolutions justifies technically such limitation or exemption with regard to vessel tonnage. Such thing may be understood 31 years ago, when the state-of-the-art of that time to control and reduce the noise on board vessels was limited. In fact, the Resolution A. 468(XII), since it imposed noise level limits, forced the Shipbuilding Industry to find technical solutions to satisfy these requirements.
  - However, it is difficult to understand why, after 31 years and considering the technical improvements achieved for the Noise Control, the new resolution has the same exemptions with regard to vessel tonnage. It has been either written by the same authors or they have the same unjustified technical preconceptions about the noise control on vessels whose tonnage is below 1600GT’s.
  - Everyone knows that the noise levels of some pleasure vessels, in particular yachts, whose tonnage is much lower than 1600GT’s, are excellent and in compliance with the strictest Comfort Class of the Classification Societies. This is a conclusive proof of there is no technical limitation which makes impossible to guaranty the workers’ health because of the vessel tonnage.
  - This "acoustical advantage" is usually associated to an added value of the ship owner’s wealth, and by means of an erroneous extrapolation, achieving reduced noise levels in small vessels is presupposed highly expensive. Once the technical feasibility has been shown thanks to the example of the yachts, it is the economical unfeasibility the only argument left to support these kind of exemptions. Difficult situation for those regulatory bodies which have to decide between the workers’ protection by means of the noise control on vessels, and the cost wrongly associated to these kind of solutions.
  - In order to break the cliché about the high cost of the noise control for all kind of vessels, which makes unfeasible this kind of solutions from an economical point of view, we encourage the reader to look for the two documented references ([14, 15]). The first one corresponds with a fishing research vessel, and the second one with a fishing research vessel. Figure 7. The ship- lengths are 27 m and 46.7 m respectively. Both vessels have a tonnage much lower than 1,600 gt’s. As it can be seen, Figure 8 the noise levels obtained are in compliance with the limits imposed by the Resolution A. 468(XII) in the first case, and with the Comfort Class Notation COMF-NOISE-1 of Bureau Veritas in the second case. The cost required to achieve these targets, including the numerical predictions and the noise insulation materials, has not exceed 1% of the total cost of the vessel for the first one, and 2% for the second one.
  - Every stakeholder: Ship-owners, shipyards, Administration, etc. must be aware that the cost associated to the application of these noise control techniques in all kind of vessel regardless of its tonnage are negligible compared to the direct costs associated with claims, social costs and medical care for the personnel affected by high noise levels. The "savings" of few people today may become personal and irreversible damage of many and unforeseen social costs paid by everyone: citizens and enterprises through the corresponding taxes.

Therefore, neither the technical infeasibility nor the economic infeasibility can support the application of exemptions because of vessel tonnage, what lead to a lack of protection of the seafarers working on them against the harmful effects of noise.

5.4. Comments on the exemptions because of tonnage. Technical obsolescence II

In almost the end of the author’s professional career, he admits his total inability to understand why the old and new resolutions
exempt the kind of vessels referred to in paragraph 1.3 of both regulations. The reasoning is very simple: if they say their purpose is to protect seafarers from the risks caused by the fact of being exposed to high noise levels, how is it possible the two most important groups, the fisherman and the navy sailors are out of the scope of these regulations? Either they are not seafarer, which would be insulting, or they do not have this risk, which would be negligent. Some people think the best way to solve a problem is not recognizing that it exists: Exemptions.

We will see soon some consequences caused by the application of these exemptions with regard to the type of vessels in the Resolution A. 468(XIII) and the future consequences if these exemptions are kept in the new Resolution MSC.337(91).

The author could not find any statistics at worldwide level so as to know the sample size subject to the risks caused by the noise exposure on board vessels. So, the number of seafarers who work in all kinds of vessels all over the world is not known. However, reliable statistical studies and data are available to question the effects caused by the exemptions with regard to the type of vessels existing since 1981.

According to different sources (BINCO/ISF), the total number of seafarers in the world merchant fleet above 2,000 gt’s were about 1,384,000 in 2010, from which 637,000 are officers and the rest of the sailors. FAO and ILO estimate that the fishing is a source of income for 28 million of people, mainly in the developing countries in Asia and Africa. The same source claims that most of these people work on vessels whose ship-length are lower than 12 m and the tonnage lower than 100 gt’s. In fact, the vast majority of fishing vessels of the developing countries have ship-length lower than 12 m. The number of fishing vessels above 100 gt’s or more than 24 m ship-length is estimated to be around 24,000, which employ about 200,000 people.

Based on these numbers and considering the Purpose of both resolutions, the “old” and the “new” one is “the Protection of the seafarer from excessive noise levels which may cause a hearing loss capability”, the application of the “Exemptions” that both regulations establish leads to the following scenario:

- This has been like that since 1981 with the Resolution A. 468(XIII), and it will keep like that with the entry into force of the new Resolution MSC. 337(91).
- If the application of both resolutions were aimed at the “Protection” of the seafarers working on those vessels to what both resolutions are applicable, clearly, the rest of seafarers are not protected from the noise exposure effects.
- Sadly, that means every fisherman, navy sailor; officers and sailors of small merchant vessels have been and will be not protected from noise on board their vessels. Moreover, this has not only happened in developing countries but also in the most advanced ones. Some consequences of this vulnerability are detailed in the following paragraphs.
- Specifically in the frame of the European Union (UE-27) in 2009, from a total of 98,598 of vessels which represents 21.3% of the gt’s at worldwide level and employ on the one hand 254.119 people on 12,965 merchant and passenger vessels (13% of the fleet) and, on the other hand, 14,110 fishermen on the 86,587 fishing vessels (87% of the fleet), just the first ones are protected by the application of the Resolutions.

This vulnerability caused by the unjustified exemptions, the lack of sensitivity of some countries and Maritime Administrations and the lack of education of the workers about the effects of the noise exposure may lead to situations as the one recently seen by the author in a riverboat (Figure 9). There is no need
of any comments to the photo taken in the machinery room of this vessel with the engines running.

Everything that has been exposed so far confirms that the "old" and "new" Resolution limit their field of applicability due to the exemptions with regard to the type of the vessel. All of this without any technical or economical reasons that justify the vulnerability of all the fisherman, navy sailors and crews of small merchant vessels.

The Directive 2003/10/EC, which makes obsolete both Resolutions, remedies this lack of protection against noise within the frame of the European Union. However, this is not the case for those countries that do not have Local Regulations. In those countries the old and new regulation are and will be in force, letting the workers unprotected against noise. This detail is a clear contradiction against the guidelines established by ILO and FAO about the minimum standards set by the Work Fishing Convention of 2005 and adopted in the 96th International Labour Conference in 2007.

6. The practical consequences of the exemptions of the code on noise. The case of the fishing vessels, analysis and "change of course"

6.1. Fishing vessels. Peculiarities from the point of view of the Noise on Board

Fishing Vessels have peculiarities, due to their dimensions, which make them especially complicated for Noise Control on board them. It is common to say that the fishing vessel is like a "box of noise", a machinery room over which beds and workspaces have been installed. A quick look at a common fishing vessel arrangement Figure 10, although it is new, allows the reader to shape his or her own opinion.

Probably, this reason, among others, was the argument which made the authors of the Resolution IMO A.468(XIII) in 1981 impose the exemptions with regard to this kind of vessels and to the smallest ones. The state-of-the-art of that time in the shipbuilding industry in this field was only a few guidelines of some Classification Societies. No prediction tool was available to obtain the expected noise levels in the different vessel spaces.

As the aforementioned second principle (after the Archimedes’ one) "Nobody does anything if they are not forced to" says the results were not long in coming. The Figure 11 shows a representative sample of the noise distribution in the different vessel spaces of a fishing vessel of that time (1987).

Likewise as these vessels were exempted by the Resolution IMO A.468(XIII), and as shown by SILENV project [10], the data collection of noise levels in these vessels was not easy. "Nobody does anything if they do not force to". Anyway, using different sources the author has been able to obtain some data of noise level in fishing vessels. These are shown in the table of Figure 12.

As can be appreciated, they are similar values to the ones of the Figure 11. According to the mentioned sources, the average values of noise level for a 24 m length trawler vessel were as follows: 76 dB(A) in gangways, 80 dB(A) in wardrooms, 86 dB(A) in steerage compartments, 84 dB(A) in fishing decks, 82 dB(A) in crew quarters or cabins and 106 dB(A) in machinery rooms.

As pointed out thanks to the different medical sources and bodies dedicated to the workers’ health monitoring, the best indicator of the risks to the hearing is the equivalent continuous sound pressure level (Leq) which the workers are exposed to during one day. According to the data given by these sources [17], during a fishing voyage on board a trawler whose ship length is between 55 and 60m, equivalent sound pressure levels of more than 85 dB(A) were obtained.

As it is explained in paragraph 2.2, the equivalent sound pressure level not only considers the noise intensity in terms of sound pressure amplitude but also the time of exposure. For the industry in developed countries, this indicator is referred to 8 hours of exposure corresponding to a workday. Thus, it is expressed as Leq [8]. According to several sources and researches, when Leq [8] exceeds 80 dB(A) is considered a risk factor for the hearing loss. This has been considered by the Directive 2003/10/EC [6] and in the transposition of it by Real Decreto 286/2006 [18] in the case of Spain. Both regulations set the lower limit value in 80 dB(A), and above that corrective actions shall be taken.

However, the seafarers are exposed to noise during 24 hours a day. So it is better to estimate the equivalent sound pressure level for a period of 24 hours to have a more accurate idea of the exposure level. Consequently and as the fishermen are on board this kind of vessel for 24 hours a day, the exposure levels considered
responsible of hearing loss in the workers on shore are not easily extrapolated to the exposure levels for the fishermen.

In addition, the exposure levels from a seafarer to another seafarer vary appreciably because they do not perform the same tasks on board vessels. The table of the Figure 13 shows the exposure levels of different members of the ship crew in four 34 m length trawlers during a trip. In this table we can see that the skipper of the vessel is the only one not subject to exposure levels dangerous for the hearing capabilities, whereas the rest of the crew are subject to a noise level which may cause hearing loss.

The recognized threshold which currently the Directive 2003/10/EC [6] and its transposition to the Spanish law by the Real Decreto 286/2006 [18] sets is 80 dB[A] for eight (8) hours from which corrective actions shall be taken. Moreover, according to the law of acoustical energy equivalence a 24 hours equivalent sound pressure level of 80 dB(A) [Leq (24)] = 80 dB(A) is equal to an 8 hours equivalent sound pressure level of 85 dB(A) [Leq (8)] = 85 dB(A) according to the formulae: Leq (8) = Leq (24) + 10 log(24/8).

This means that a seafarer who is exposed to a noise level of 80 dB(A) for 24 hours, is subject to a risk for his hearing equal to the one of a worker exposed to 85 dB(A) for 8 hours a day.

The Figures 14 represents graphically the data of the exposure level of seafarer of the fishing vessels with the maximum level of exposure recommended and established by the current Directives. As can be seen the ship crew is subjected to higher levels than 80 dB(A), the minimum value that guarantees their hearing health. It is especially remarkable the case of the chief engineers of this kind of vessel whose exposure levels are 15 dB[A] higher than the minimum level required, which is a high risk of suffering from hearing loss. The author has noted this fact in his professional relationships with this group. They actually recognize this fact arguing that, for safety reasons, they “need” to hear the main diesel engine meanwhile they are in bed.

Finally, based on the available data, we can estimate the average noise exposure level for 24 hours in a vessel like this. We can find that in the noisiest periods of the workday when the fishermen are on the deck fishing, repairing fishing nets, etc. they are exposed to an average noise level of 85 dB(A) for an average period of time of 13 hours a day. Then, while they are resting in their quarters they are exposed to 83 dB(A) for 5–6 hours. Besides, while they are eating or doing any other recreation activity, to an average level of 81 dB(A) for 3 hours. Finally, considering 2 hours in the bridge of a standard fishing vessel where the seafarers are exposed to 73 dB(A) of noise level we have a total 24 hours equivalent sound pressure level of 83.6 dB(A).

Therefore, according to the available data, the fishermen are generally subjected to noise exposure level above the maximum levels recommended (80 dB(A)), which means they are part of a group of seafarers not considered by either the Resolution A. 468(XII) or by the forthcoming MSC-337[91].

6.2. The effects on the Hearing of the Fishermen. Scientific findings

For this paragraph, which is far out from the specialization of the author, international scientific studies have been consulted. The reader can find them in the references [17], [19] and [20]. In addition, as was previously mentioned, the medical studies have shown that if a person is exposed to noise levels higher than 80 dB(A) for 8 hours each day he or she may develop hearing loss in one or both ears over time. This damage tends to get worse as the exposure is extended in time. The damage may even affect the high frequencies around 4000 Hz.

In the merchant vessels, the most exposed to noise are the engineers because of their activity. According to the available data, they are exposed to average levels above 85 dB(A). An audiometric study carried out in 1984 [21] concluded that in the audiograms of the marine engineers of the merchant vessels an appreciable hearing loss around the 4,000 Hz band appeared. This was more significance for the marine engineers over forty years of age (Figure 15). The rest of the seafarers who performed other activities do not have any appreciable affection.

The study also showed that between marine engineers of the same age, those who were working have less hearing loss than those workers who were subject to exposure levels of 95 or 100 dB(A) during eight hours per day.

A more recent study (1998) [22] reveals that 26.8% of the engineers present significant hearing loss, compared with 16% of the deckhands and 9.9% of the supervisors. These differences were statistically significant.

It is important to note that these moderate levels of hearing loss observed in the engineers of the merchant vessels can be explained by the fact that their exposition to the engine noise is attenuated by the presence of acoustic isolation in the central cabins of the machinery rooms. Indeed, the exposure to significant noise levels is limited to the periods of time when the engineers perform maintenance activities, during of which they wore ear protectors. Besides, if the noise is constant of slightly fluctuating, the effects are less severe. Finally, if the period of work of this group is only during 2–3 months followed by a period of rest of the same duration, the likelihood of developing hearing loss is significantly reduced.

More recent studies (2008) performed by Kaurleve et al. [23] have shown that the engineers, among the Danish seafarers, have a relative risk of hearing loss of 2.39 compared to other seafarers dedicated to other activities.

However, the scenario on board fishing vessels is quite different. As pointed out previously, the studies of Andra and Dorval [12] performed in 1984 have shown that the crew of these vessels are continuously exposed to noise levels during the 24 hours of the day. If we take the average value for a vessel of this kind, we can obtain that the seafarers are exposed to levels between 84-86 dB(A) when they work on the deck. 76 dB(A) when they are in the gateways and 82 dB(A) during their period of rest in their quarters.

In parallel to this study, an audiometric study in 113 fishermen at sea on this kind of vessels was performed [24]. It shows hearing loss around the 4,000 Hz band which was more severe as the age of the affected ones and the time of duty. The measured hearing losses were compared to the French Norm NF-5-31-013 which includes estimations of the hearing capabilities of the workers over 40 years old who were exposed to constant levels of industrial noise of 90, 95 and 100dB(A) for 20 years. The Figure 16 summarizes the results obtained.

Figure 15. “Audiograms of the marine engineers by age (Average level of both ears) [21]”
The Figure 16 shows the hearing loss of the fishermen over 40 years old and 23 years of duty are around high frequencies (3000, 4000 and 6000Hz), being the lowest frequencies the most affected. Taking into account, as pointed out previously, that a noise exposure level of 90 dBA during 8 hours is equivalent to a noise exposure level of 85 dBA during 24 hours, the results of these studies and the hearing loss identified in the seafarers of the fishing vessels are the clear proof that these seafarers are subject to exposure levels of 85 dBA or higher during 24 hours a day. All of this confirms that the fishing activity has a higher risk of noise induced hearing loss.

If all of these prove were not enough, recent studies (2006) by F. Trécan [20] on the audiometric tests of more than 18,000 French seafarers, and by Kaerlee [23] in 2008 confirm the conclusions of previous studies about the higher risk of the fishermen with regard to merchant seafarers of suffering from hearing loss.

This risk was already recognized by the European Parliament report on 12th March of 2007 about safety and accidents in the maritime fishing, which pointed out “the continuous noise creates an aggressive climate on board which means fishermen sleep little and bad so it is difficult to rest what they need, and they may be affected by hearing losses”.

6.3 The consequences of the “Exemptions”. Analysis

At this point and based on the above we may think that the problem of the high exposure level of noise in the fishing vessels is just a problem of personal protection as these vessels do not have machinery control room. The machinery control room would attenuate the noise levels by means of acoustical insulation so the most affected members of the crew (the engineers) could be exposed to lower noise exposure levels.

Besides, we have seen that the seafarers who work on fishing vessels are exposed to noise levels between 84-86 dBA during 13 hours which may condition their exposure levels unless they spend sufficient time in their quarters where they are exposed to lower noise levels (82 dBA).

Some studies about this [25] have shown that personal protection can be effective if the crew wear individual protector during 24 hours a day. This is not very practical and more important; it may lead to communication problems, misidentification of alarms and acoustic signals. The author considers convenient overview the following aspects to analyse the scenario of the fishing vessels and the health risks associated with high noise exposure.

Technical immobility and lack of prevention: It is understandable, as explained before in this paper, the first Resolution (A. 468(XIII)) on Noise Level On Board Ships included exemptions for a list of type of vessels because the state-of-the-art of that time did not allow to deal with the noise control. However, the conservation of the same exemptions over time, even though many reliable scientific and medical studies have been providing data about the problem, can be considered as negligence. Besides, it has caused the following:

- Technical immobility: Firstly, some people came to think that if IMO did not do anything to change this was because there were no reasons to do it. IMO was unquestionable and any consultant was nobody to question it. Consequently, as established by the aforementioned 2nd principle, the technology did not feel forced to introduce modifications or changes.
- Cultural immobility: If IMO did not force to, and the fishing business were well, it was extremely difficult that the ship owners requires changes in the vessel design. The current fishing vessels are, acoustically speaking, the same as thee decades ago. Besides, nowadays it is almost impossible to persuade a ship owner of a tuna vessel which fishes in Africa to change the support of the main engine and the freezer units to reduce the structural noise and, in consequence, to improve the noise on board and even the underwater acoustic footprint. Just the impossibility of selling their vessel in a regularized space as the European Union makes them question that positioning. They will start to “move”.
- Lack of prevention: The policy of not listening to the warnings coming from international bodies and agencies based on medical studies and reliable data are the only possible explanation the author finds for such regulatory immobility and the conservation of the limitations with regard to vessel size and type of vessels of the Resolution A. 468(XIII).

The fact that it was impossible to consult the initial and periodic audiometric tests administered by a trained and qualified person to the satisfaction of the Administration that the old Resolution provides in its paragraph 5.5 “Hearing Conservation Programme”, makes impossible to assess the reliability and effectiveness of the protection of the seafarers provided by it.

However, without questioning the effectiveness of the prevention and protection of the old Resolution, there is no doubt about the fact that the majority of the seafarers made up by fishermen, crews of warships and merchant seafarers of small vessels (<1,600 gts) have been left unprotected against the harmful effects of high noise exposure levels at worldwide level.

The economic and social consequences: It has not been possible to find any data to quantify the total number of fishermen and navy sailors who suffer from noise induced hearing loss from all the consulted sources. What is unquestionable, as can be seen above, is the fact that fishermen have been exposed to noise exposure levels for 8 hours above the value of 85 dBA which the Resolution established as a limit for this period of time and thus above the current limit of the Directive 2003/10/EC, from which corrective actions shall be taken.

Moreover, there is also a social impact because of the social costs associated to this disability. However, it has also been impossible to quantify as the available data are too generic which makes difficult to compute this cost.

Perhaps, as an indicator of this aspect, we can use the data provided by the Veteran Association (VA) of the US Navy which shows that the budget for this kind of deficiencies reached 6.48 billion of Dollars for a group of 107,000 sailors from 1966 to 2006. Any Navy can estimate their corresponding value
considering that the ratio is 1,500 $ per year and sailor.

Regulatory and Technical Obsolescence and Unbalanced Protection: The forthcoming entry into force of the new Resolution MSC.337(91) for the next 1 of July of 2014 has the following particularities:

- Technical obsolescence: The analysis of the technical aspects of this Resolution, which are almost the same as in the old Resolution A.468(XIII) of 1981, makes clear that, contrary to what is thought, the new Resolution will not drive any significance change in the acoustical design of the vessel. Moreover, the weak declarations focused on aspects like improvements on the vessel spaces privacy or the convenience of performing numerical predictions in the design stage of the vessel will not be applied as the Resolution only recommends them and let the Administration the body what decides. The “technical and cultural immobility” will continue.

Finally, it is frustrating and remarkable that the new Resolution has not been capable of including not only the contrasted experiences of the experts on Noise Control On Board Vessels, but also the achievements got by the Comfort Class Notations with regard to noise reduction in cruisers and even merchant vessels whose sensitive ship owners require it in the Contract Specification. In fact including these requirements in the Contract Specifications becomes essential for achieving acoustical design improvements on these vessels.

Currently the practical consequence is any sensitized or forced shipowner with the fulfillment of the targets of protection of their workers only mentions this resolution as a procedure methodology but requires stricter limits in the contract specifications: Comfort or flag requirements. Summarizing, both Resolutions are technically obsolete. More data to support this conclusion will be presented later on.

- Regulatory obsolescence: As seen above, the new and old Resolution have become obsolete within the European Union because of the Directive 2003/10/EC [6]. According to its provisions, this directive has been transposed in the different Member States, as in Spain, with the Real Decreto 286/2006[18] or in UK, with the “CO BO ODE OF PRACTICE ON NOISE AND VIBRATION IN SHIPS” of the MCA.

Both the initial Directive and its corresponding transpositions are focused on the protection of the “personnel on board seagoing ships”, without any exemption or limitation with regard to tonnage, type or age what can diminish their universal character of protection of the seafarers. Therefore the old and new Resolution have become obsolete from a regulatory point of view because of their limitations and exemptions.

As an example of protection without any limitation, the Resolution 2007 of the MCA is noteworthy, as it is applicable not only to British vessels but also any vessel what is in British waters.

- Unbalanced Protection: As some International bodies have pointed out, “the noise exposure effects are independent on the geographical location”. Taking into account that the old and new Resolutions have become obsolete from a regulatory point of view, their applicability will be only in those countries where there is no a similar regulatory framework.

Therefore, European fishermen are protected whereas their counterpart in other countries will not. The same will happen also to the merchant seamen of all kind of small vessels as well as the crews of navy ships who are out of the scope in the new Resolution MSC.337(91) because of the included exemptions.

The reaction of some Navies of developed countries has been quick due to the economic and social consequences and the results of different studies. Currently this Navy have set the strategy of “change the trend” known as “Buy Quiet”.

Finally, all the developed societies must be aware of this scenario of regulatory unbalance, besides of being a clear contradiction with the principles enacted by ILO, causes an economic unbalance in a globalized economy as the current one: The “noisy industries” as the fishing industry will move to countries with less strict regulatory framework. What “we do not want for ourselves we should not want for others”.

6.4. The change of “Course”

This paper may catch the attention because of its title, but inconsistent if we do not present proposals, alternatives or reliable solutions to improve and try to solve this scenario of Noise on board vessels. Thus, we can technically support the previous evaluation of the exemptions of the Resolutions IMO A.468(XIII) and MSC.337(91). In particular, those concerning their obsolescence with regard to the technological improvements achieved by the Shipbuilding industry during the last three decades.

As mentioned, the professional life of the author has been developed within this scenario, and in parallel making a labour of dissemination many times ungrateful because of the little attention paid especially by those who can lead the change. They have remained immutable to the notices[26, 27] necessities and requests, until the new European regulatory framework has forced them to start moving quickly. In this sense, it is not surprisingly the concern of some Administrations about who shall implement the provisions and how they shall be implemented, especially in the old vessels.

Then, the following paragraphs could be also used as “Preliminary Practical Guide of Application and Fulfilment of the Directive 2003/10/EC in vessels”. This could be useful for ship-owners and even for the Administration. The new contract requirements required by the ship owners to the shipyards shall be implemented taking into account their strict compliance the Administration shall verify.

The foundations of this first proposal are the results obtained from the practical experience of the author and the methodology designed by himself to reduce noise and vibration on board, from some researches and conclusions drawn in the projects BESS [9] and SILEV [10] and from proposals about the management of the noise problem for old vessels to the EU, which had not favourable acceptance yet.

6.4.1. Shipbuilding Industry ready to face the Regulatory Framework: The New Silent Vessels

The author has mentioned a lot of times the capacity of the Spanish Shipbuilding Industry to design and build vessels in compliance with the strictest requirements of the new European Regulatory Framework not only with those regarding noise and vibration on board these vessels, but also those regarding the radiated noise to environment: Noise Radiated to Harbour and Underwater Radiated Noise, especially taking into account the new Directive 2008/56/EC [8]. We encourage the reader to consult these references [16] [26] and [27].

On the other hand, the Figure 17 shows a list of examples of different types of vessels, some of them out of the scope of the IMO Resolutions. The ship owners of these vessels required the compliance with strict noise limits and much lower noise levels than specified by the new IMO resolution MSC.337(91) were achieved. The case d) because of specific requirements of the ship owners for complying with the Comfort Class Notation Grade 3, the case b) as preventive actions to face the immediate entry into force of the Directive 2003/10/EC [6] and finally the cases a) and d) where the Spanish and Venezuelan Navy decided unilaterally to protect their navy ship crews.

The cases b) and d) are noteworthy. In the first one, exhaustively described in the reference
the price of these vessels in the second-hand markets will be higher than the cost of the vessel whose ship owners had not been adapted to the new Regulatory Framework.

And this trend for the last 25 years, besides driving the technological progress on the field of Noise and Vibration Control in ships, has shown the technical obsolescence of not only the old Resolution A. 468(XII) but also the new one MSC-337(91).

Finally, and with the aim to configure the aforementioned “Preliminary Practical Guide of Application and Compliance with the Directive 2003/10/EC in vessels”, it is important to mention that the Naval Engineering has a “reliable tool” not only for the design of new vessels in compliance with the strictest requirements of the new Regulatory Framework, but also to identify deficiencies of the old vessels and propose corrective actions to solve these deficiencies.

At this point, the reader will surely have noticed that we have shown the invalidity of the exemptions of the new and old Resolution regarding the “type of ship”. However all of the vessels shown in the Figure 17 are above 1600GT, thus within the scope of both resolutions. The task of showing the unsuitability of the exemptions with regard to vessel tonnage or size will be developed in the following paragraph.

6.4.2. Inconsistency of the “Exemptions” by size. Technical and economic feasibility for the construction of Silent Fishing Vessels

In this concern a “warning to seafarers” was launched by the author in 2006 [14] as a result of the successful experimental data obtained, detailed later, on board the fishing research vessel “Emma Bardon” of the General Secretariat Spanish Fisheries Administration. On it and based on what was coming as a suggestion the following question was presented:

“Why do comfort levels (noise) on a fishing vessel not have to be, at least, equal to those of other workplace?”

The convenience of using the positive experience of this ship as a “technological reference” for future construction of this type of vessels in compliance with the Directive 2003/10/EC was pointed out. Perhaps those who today are having problems on transferring their vessels to other Member States in compliance with the provisions of the Directive will possibly regret not having been able to hear these suggestions.

In parallel the participation of the author since 1997 in the dynamic and acoustic design of five fishing research vessels in strict compliance with the IES No 209 Underwater Radiated Noise Regulation has enabled to verify and validate the effectiveness of the “Noise & Vibration Comprehensive Management” tool developd by him. As an “other warning, more”, in order to anticipate to the appearance of Directive 2008/56/EC [8] and the proposed IMO (in preparation), regarding the control of Underwater Radiated Noise by all types of vessels, including merchant or commercial, the “lessons learned” from these practical experiences have been nationally and internationally published [27]. Special mention could be done to the publication in the ASA (Acoustic Society of America) related to the Fishing Research Vessels Ramon Margalef of the IED-Spanish Oceanography Institute. The experimental data published including its “underwater footprint” enable to qualify this ship among the most silent in the worldwide.

Both vessels previously mentioned are included in the Figure 7. The corresponding experimental data that will be detailed below are enough to demonstrate the “technical inconsistency” of the exemption with regard to vessel tonnage made in the Resolution MSC. 337(91). Likewise, these experimental data enable to emphasize the current capability of the Shipbuilding Industry to attend not only the compliance with the Directive 2003/10/EC but also with the strictest Underwater Radiated Noise requirements (ICES No 209). Further proof of the soundness of the above is the fact that both vessels have been selected as “technological references” within the framework of SilEnv project [10].

In the author’s opinion, these issues previously discussed, in particular those related to noise levels on board smaller vessels, including fishing, should be considered in the aforementioned “Preliminary Practical Guide of Implementation and Compliance” with the Directive 2003/10/EC in Ships. And if this work caught a minimum of attention, a similar Practical Guide, in order to attend the new requirements concerning underwater radiated noise by the ships in accordance with the Directive 2008/56/EC [8] should be considered. This is precisely one of the tasks of the new ongoing project AQUO [11] “Achievement Quieter Oceans”, and which the author is involved in.

On the basis of the foregoing let us prove the “technical and economic feasibility” on reducing noise levels on board ships of gross tonnage below 1,600 gts, and therefore all kinds of fishing vessels. The data provided are sufficient, at least, to demonstrate the technical inconsistency of the exemption included on both Resolutions, the new and old one related to the ship size. The main goal of this task rather than a limited or simplified technical discrepancy...
between an organism as prestigious as the Maritime Safety Committee (MSC), which deserves of all the author’s respect, and this modest naval architect, is to make think about the potential consequences that an important group of seafarers such as fishermen, navy men and other seamen could have suffered, due to the vulnerability resulting from the “exemptions” established. And if any risk were identified, to contribute on avoiding its temporary perpetuation.

For both vessels mentioned previously and with small modifications depending of the particular requirements for each project, the same methodology “Noise & Vibration Comprehensive Management” has been applied. The main modules have been summarized in the Figure 18 and the practical description of their development are detailed in different references [14,16,26]. The experimental noise levels obtained on board these two ships as results of application of the methodology described are summarized in the attached Figure 19.

As validation of the tool used, the calculated and the experimental values obtained during the Sea Trials of the fishing vessel (Emma Bardán) are presented.

The first significant achievement is the appreciable noise reduction for this kind of vessels. Indeed, the Figure 20 shows the noise levels distribution of a fishing vessel of the 80s, where “nothing has been done” due to the “absence of requirements”, and the corresponding one to the Emma Bardán as representative of a vessel of this type where, due to strict noise requirements stated by the ship owner, the appropriate methodology for achieving them was indeed applied.

As can be seen the noise levels in the “fishing treaty”, whose ship-length is 27 meters, have been reduced an average of 26 dB (A) in the cabins and 17 dB (A) in the fishing deck if they are compared with the data provided by Andro and Dorval [17] for a trawler of 26 meters in length without any preventive measure. This also means, as it will be seen below, a drastic reduction in the noise exposure levels for the member of the crew of new vessel with regard to the old one and thus less risk to the health of the first. “Noise reduction” reaches average values up to 28 dB (A) when comparing the cabins of the Fishing Research Vessel with those of the trawler of similar dimensions (55 meters length). Figure 12.

Based on the experimental noise levels obtained on board the two vessels, the fishing and the FRV one, the noise exposure levels during 24 hours for a representative sample of the crew members of both: Captain, Chief Engineer and Sailors, have been calculated. Both calculations have been done assuming the use or not of personal protective devices, Figures 21 and 22.

The exam of both Figures 21 and 22 enables to highlight the following aspects:

- For the Fishing vessel Emma Bardán noise exposure levels during 24 hours of the different considered members of its crew: Captain, Chief Engineer and Sailors not wearing “no individual protection device” 59.2, 97.4 and 64.5 dB (A), respectively. It clearly shows that despite the significant reduction of the resting spaces of the Chief Engineer with values of 59.9 dB (A) at mess room and 58 dB (A) in his cabin, this occupation (chief
engineer) remains the most exposed to the risk of hearing loss due to the high noise exposure levels obtained. And all this is derived from considering an “extreme occupation” of 8 hours on Engine Room “unprotected”.

- The comparison of these noise exposure levels for the crew of Emma Bardan as representative of a modern fishing vessel, with the average noise exposure values of the crews of the four trawlers detailed in Figure 13 reveals that a significant reduction of the noise exposure levels up to 14 dBA for the Captain and 19.5 dBA for the deckhands have been obtained, the noise exposure levels of the Chief Engineer remain almost unalterable.

- Based on that and as it will be confirmed by the comparison of the results corresponding to the two vessels analysed, unless there is any improvement of the sound power values of the main noise source: Main Diesel Engine, the Chief Engineers will be the highly exposed to noise so their protection will require to adopt complementary and special countermeasures.

- Indeed, as can be seen by examining the levels of noise exposure when Chief Engineer operates 8 hours in machinery spaces wearing “protectors”, the noise exposure level during 24 hours drops to 76.3 dBA. Consequently a limitation of exposure time in these noisy spaces of less than 4 hours/day wearing appropriate protection, combined with surveillance on the bridge (in the absence of a Machinery Control Room) reduces significantly the noise exposure level and therefore hearing loss risk.

- Finally, the exposure levels of the crew of the fishing vessel “Emma Bardán” adapted by the equivalent energy law to eight (8) hours, allow to obtain values of noise exposure levels during eight hours of 64.0 dBA, for the Captain, 69.3 dBA, for sailors and 80.8 dBA for the Chief Engineer, therefore in accordance and in compliance with the Directive 2003/10/EC limits [6] and the Royal Decree 286/2006 [18]. The slight deviation at 0.8 dBA (A) related to noise exposure level during 8 hours for the Chief Engineer, slightly above the lower limit of 80 dBA (A), which would lead to a corrective action, can be successfully modified with the actions that have been described in the preceding paragraph.

- In the case of the FRV Ramon Margalef, the noise exposure levels during the 24 hours to different members of her crew, and for the less conservative condition (no personal protection for the Chief Engineer), take values of 50.9 dBA for Captain, 65.7 dBA for the Mariners and 72.9 dBA (A) to the Chief Engineer. These values are 22.1 dBA (A), 18.6 dBA (A) and 21.9 dBA (A), respectively below the average of noise exposure levels corresponding to the same occupations of the four trawlers detailed in the Figure 13.

- Similarly, the previous noise exposure levels for 24 hours have been adapted by the equivalent energy law to eight (8) hours of exposure time. It enables to obtain values of 55.7 dBA (A) for the Captain, 70.5 dBA (A) for the Sailors and 77.6 dBA (A) for the Chief Engineer. As it can be seen all these values, and for the less conservative condition: No personal protection for the Chief Engineer during his three-hour of surveillance at different machinery spaces, are below the lowest limit (80 dBA (A)) established by the Directive 2003/10/EC [6] and the Royal Decree 286/2006 [18].

- And all this has been achieved with the provision of an adequate isolated space such as the Engine Control Room and the proper acoustic treatment not only in the Engine Room but also in the main noise sources through its structural and airborne noise insulation.

To conclude in the previous paragraphs has been summarized the experimental data corresponding to the two vessels analysed with dimensions of 27 meters in length for the fishing vessel and 46.7 meters in length for the fishing research vessel, and in both cases with gross tonnage below 1,600 gts. Thus both vessels are out of the scope of application of the Regulations A.468(XII) and the new one MSC. 337(91), according with the “exceptions” included in them. However the noise experimental data obtained on board both vessels as result of the proper application of the methodology of Noise Control are enough to demonstrate the technical inconsistency of both “exceptions”: by “size” and by “type of ships” that have been maintained by the Resolution A.468(XII), over the last three decades of constant evolution and Shipbuilding progress in the field of Noise Control on Ships, and which is intended to perpetuate in time with the entry into force of the Resolution MSC.337 (91) next July 1, 2014.

And once the “technical feasibility” on achieving silent ships regardless its dimensions and type has been demonstrated, the author would like to show his surprise when in one dish of the balance we put the individual and social costs, as it has been reviewed in this paper, can produce the vulnerability generated to all the seafarers without any type of discrimination by the application of the “exceptions” of Regulations, and in the other dish of the balance we put the estimated costs in less than 1% or 2% of the price of the ship of the preventive actions for the vessels analysed which are able to get noise exposure levels for the member of their crews similar, at least, to those of other workers in other workplaces, and thus, fulfilling the current law in force. The possible “economic infeasibility” as an argument for doing nothing is not consistent.

7. Conclusions

From the above, technical and experimentally documented and supported, the following conclusions could be highlighted:

- Resolutions A.468(XII) from 1981 and the new one MSC.337(91) that will come into force in 2014, with regard to the “Code of noise levels on board ships” and aimed both at the “protection” of the “seafarers” against the effects on their health of high noise exposure levels, have become obsolete from the “technical” and “regulatory” points of view. The first due to time and the second one before birth.

- From the “regulatory” point of view, both resolutions become obsolete, firstly, due the appearance of the Directive 2003/10/EC in the field of European Community and its corresponding transposition to different Member States, which in Spain has been materialized as Royal Decree 286/2006, dated on 10 of March, “about the safety protection of workers from risks related to exposure to noise”. In fact and meanwhile the referred Directive and their corresponding transpositions are intended to protect “all personnel on board seagoing ships” regardless of vessel type, size and even age, both Resolutions A.468(XII) and MSC.337(91), due to the “exceptions” included on them related to “size” and “type of ships” are limiting their “real scope” of protection to only “few seafarers” (less than 5%), those on board merchant ships above 1,600 gts.

- Secondly, as a consequence of this regulatory overflow in the European area, the geographic scope of application of both Resolutions is reduced to emerging or developing countries with laxer or non-existent regulations. This violates the primary goal of the International Labour Organization with regard to the protection of “all workers without discrimination”.

- From a “technical” point of view both Resolutions become obsolete because, as it has been evidenced in this paper, Shipbuilding Industry in the last 31 years, particularly the Spanish one, has demonstrated their ability to respond successfully to the technological challenge to achieve and produce vessels, of all kinds ensuring environmental conditions without risk to the health of all the seamen who work on them. The right application of the Noise Control techniques to achieve comfort Noise and Vibration levels on board cruise ships, yachts and pleasure craft, in special vessels such as research vessels and merchant ships, when they have been requested by centralized shipowners and flag requirements are consistent proof of this capacity.

- Therefore, there is not “technical infeasibility” or even “economic infeasibility” that enables to justify the non-application of the noise control actions on achieving the goal of protection against noise of all seafarers on board all type and size of vessels. As it has been shown the cost of the application of these preventive actions, around 1% or 2% of the total price of the ship, it is insignificant compared to the costs of “vulnerability.” We must not forget that the “saving of a few and for today”, may
results over time, to high costs for those directly affected and to the States and the rest of the citizens”.

- In the author’s opinion, all these previous “weaknesses” make the forthcoming Resolution MSC-337(91) “Adoption of the Code of Noise levels on board ships” a simple “basic agreement”, contradictory with the current Directives and “universal goals of protection of” all workers “against noise as harmful agent. Likewise, it is “technically obsolete” with regard to the current level of knowledge of Shipbuilding Industry, and already is being overwhelmed by reality. The current specifications of the European Ship owners with regard to Comfort requirements or similar and the strategies launched by different Navys such as U.S Navy with the “Buy Quiet Program” confirm it.

- Last but not least, the author wishes to recall the “cry” made in the past to the maritime community and in particular to the European Commission during its participation in the SILENV project, about how to accommodate the application of the Directive 2003/10/EC to “existing ships” with a mean age of some segments of the fleet around or exceeding 24 years. Based on the research carried out two basic pillars were proposed: 1) Launching of a “Noise Management Program” that enables to diagnose the current situation and to implement feasible solutions to mitigate it, and / or 2) To open, once and for all, the feared debate about the “renewal” of an obsolete fleet most according to recent environmental requirements.

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References


[9] BESST: “Breakthrough in European Ships and Shipbuilding Technologies” project founded by the EC within the 7th FP.

[10] SILENV- “Ships oriented Innovative solutions to Reduce Noise & Vibration”, project founded by the EC within the 7th FP.

[11] AQUO- “Achievement Quiet Oceans” project founded by the EC within the 7th FP.


[18] Real Decreto 286/2006, de 10 de marzo, sobre la protección de la salud y la seguridad de los trabajadores contra los riesgos relacionados con la exposición al ruido.


