Proceedings of COBEM 2003
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17th International Congress of Mechanical Engineering
November 10-14, 2003, São Paulo, SP

ACOUSTIC PREDICTIONS IN OFFSHORE PLATFORMS

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Abstract. *Health, comfort and the job efficiency of the crew of offshore platforms are factors deeply related to the acoustic quality of the places. The acoustic project of platforms include the noise prediction. In fact, it is a complex problem,because it involves several noise sources and receptors. Numeric methods such as Boundary Element Method and Finite Element Method are not still fully satisfactory for use in complex acoustic problems. This way, semi-empiric formulas should be used in the prediction calculations.*

This paper describes calculation methodology applied and the results of the prediction performed in offshore platforms of the FPSO type (Floating, Production, Storage and Offloading) and semi-submersible units are analysed. Background noise, HVAC system noise, Structure borne noise and Airborne noise contributions are considered and the obtained final levels are compared with requirements of the international regulations. Sensibility analysis can be performed since the acoustic effects of the others insulation materials can be checked in some places. Finally, in this work, some important decisions are discussed for improvement of the acoustic quality of offshore platforms

Keywords*. acoustic, airborne, structure borne, offshore platforms, noise control*

1. Introduction

The effect of noise on people regarding to hearing loss and communication has been studied and design criteria established through extensive habitability research in offshore structures design. The effect of noise annoyance is, however, not as well defined. The wide range of noise levels that various persons find disturbing does this aspect of noise control more subjective and difficult to define.

The interior environment aboard ship and offshore platform are controlled to provide an atmosphere that is suitable to the crewmembers and passengers. The environment may be modified by means of ventilation, heating, cooling and dehumidification or by any combination of these items. Additionally, the elements of noise and vibration must be controlled. The means of controlling these environmental factors must be as reliable, simple, and maintenance free as practical, consistent with the desired results.

The acoustical aspects of controlling the ship's interior environment must be included in initial design stage. In many cases, it is extremely difficult and expensive to correct a noise problem whereas the impact of precluding the problem at the early design stage would be minimal.

2. Noise Prediction in Offshore Structures

Along the years the project of ships and offshore platforms has been modified sometimes altering sensibly the noise context of these structures. It is possible to mention, for instance, the transposition of the superstructure from the mid ship to stern ship region. In this configuration, noise sources are closer of the accommodation areas of the ship. On the other hand, warehouses, workshops, freezers rooms, garbage rooms, paint shops, among others, are placed in the main deck of ships / offshore platforms in order to act as acoustic barriers.

Figure (1) shows a typical offshore platform layout nowadays. The main noise influences of a platform of the type FPSO (Floating, Production, Storage and Offloading Unit) are pointed. Observe that the noisy machines are located in the areas Utility Plant (where are placed the vital systems of platform operation) and Process Plant (where the mixture water+oil+gas from the oil well is processed).

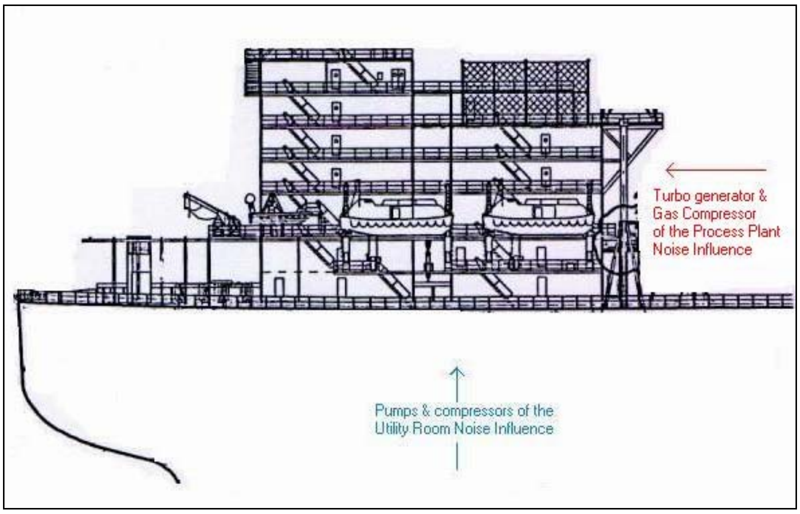


Figure 1: Main Noise Influences

Noise in ships and offshore platforms can be divided in four fundamental items, as shown in the figure 2. In the same figure important references are highlighted for the determination of each one of the parcels.

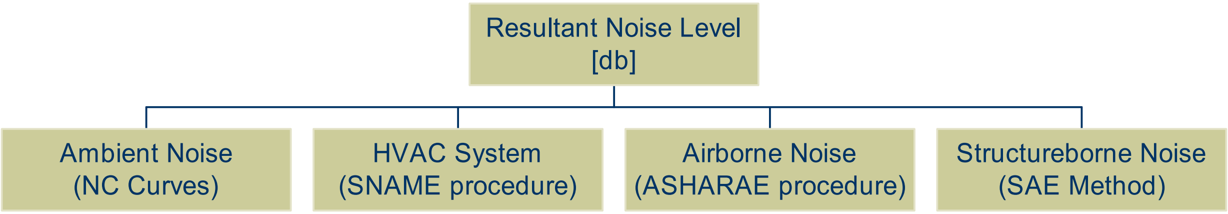


Figure 2: Noise Items

NC (Noise Criteria) or NR (Noise Rating) Curves were developed by Beraneck. These curves can be used for determination of the appropriate background noise level to each place. The other three items are discussed as follow.

3. Airborne Noise Calculation Metodology

Airborne noise prediction has been performed by A Noise software. A-Noise was developed by authors and its calculation procedure includes insertion loss, sound power levels, source-receptor distance, room volume, and noise directivity, among others.

In Fig. (3) the point A represents the noise source and the point B represents the receptor. Let us consider two situations: In the first (figure 3a) the source and the receptor are placed in free field. In this case, the main mechanisms of noise attenuation are the distance source-receptor and the air conditions. In the second situation (Fig. (3b)) barriers are placed between the source and the receptor. Now, it can be said that the inclusion of these elements in the path between A and B should alter noise attenuation significantly between these points. The increase of noise attenuation (or noise reduction) between A and B can be called Insertion Loss.

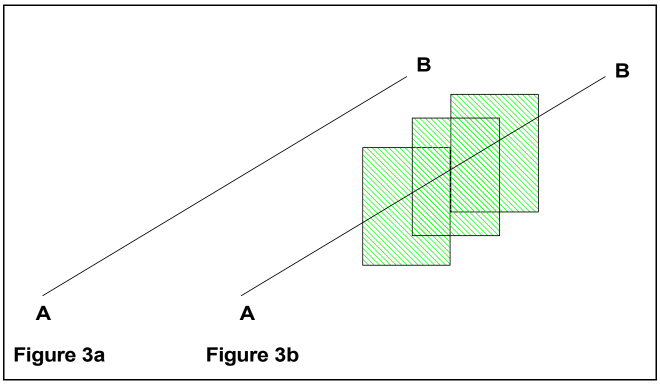


Figure 3: Insertion Loss

In agreement with Bolt and Ingard (1957), "Noise reduction is achieved by inserting some element into the system. The consequence is measured quantitatively in decibels by the insertion loss J, the amount by which the sound pressure level at a specified point is reduced by the insertion of the element, holding all other conditions constant."

Three types of factors govern the magnitude of the insertion loss:

1. Physical characteristics of the element itself (stiffness, mass and internal damping in walls, for instance);
2. Environment of the element (geometry and absorptive characteristics of the surround rooms);
3. Behavior of the noise source (constant pressure, constant particle-velocity or constant power and source noise directivity)

It is assumed diffuse field hypothesis. Diffuse sound field is one in which the average sound pressure is essentially uniform in throughout the space and the sound energy flows with equal probability in all directions. Diffuse conditions are met whenever the DSF factor is greater than unity:

$$DSF = \frac{Vf^2}{10^8 T_{60}} \tag{1}$$

where: V is room volume in cu ft; f is frequency in Hertz; T_{60} is reverberation time in sec;

Let us suppose two rooms one of which containing a noise source and the other a microphone. Between two rooms, there is a wall whose insertion effects we want to measure. If the noise source generates a constant power W, the mean square sound pressure before inserting the wall is:

$$p_0^2 = \frac{4\rho_0 cW}{a_1 + a_2} \tag{2}$$

where:p_0 is sound pressure before wall insertion; $a_1 + a_2$ are total absorption in rooms; ρ_0 is a density of air; c is the velocity of sound;

After the wall is inserted, the power is dissipated in different amounts in the two rooms. Since p_1^2 and p_2^2 are the mean square pressures in the source and receiver rooms respectively, then:

$$W = \frac{p_1^2 a_1 + p_2^2 a_2}{4\rho_0 c} \tag{3}$$

From diffuse room theory, the sound pressures ratio is given by:

$$|p_1|^2 = \frac{a_2}{\tau S}\left|p_2{}^2\right| \tag{4}$$

where: p_1 and p_2 are sound pressure in rooms 1 e 2 after wall insertion; τ is transmission coefficient

Substituting the equations 1 and 2 in 3, we have:

$$\frac{p_0^2}{p_2^2} = \frac{a_2}{S}\left[\frac{\left(\frac{\tau S}{a_2}\right) + \left(\frac{a_1}{a_2}\right)}{1 + \left(\frac{a_1}{a_2}\right)}\right] \tag{5}$$

Finally, the insertion loss for constant power is then:

$$J = 10\log\frac{p_0^2}{p_2^2} = 10\log\frac{a_2}{\tau S} + K \tag{6}$$

in which K, 10 times the log of the bracketed factor, in (5), plays the role of a correction term for insertion loss at constant power.

Observe that if we multiply (4) for 10 times log in two sides of the equation, we have:

$$10\log p_1^2 - 10\log p_2^2 = 10\log\left(\frac{a_2}{S}\right) + 10\log\left(\frac{1}{\tau}\right) \quad (7)$$

Writing in another way:

$$L_1 - L_2 = 10\log\left(\frac{a_2}{S}\right) + T.L. \quad (8)$$

where: L_1 is sound pressure level in source room; L_2 is sound pressure level in receiving room;

Then:

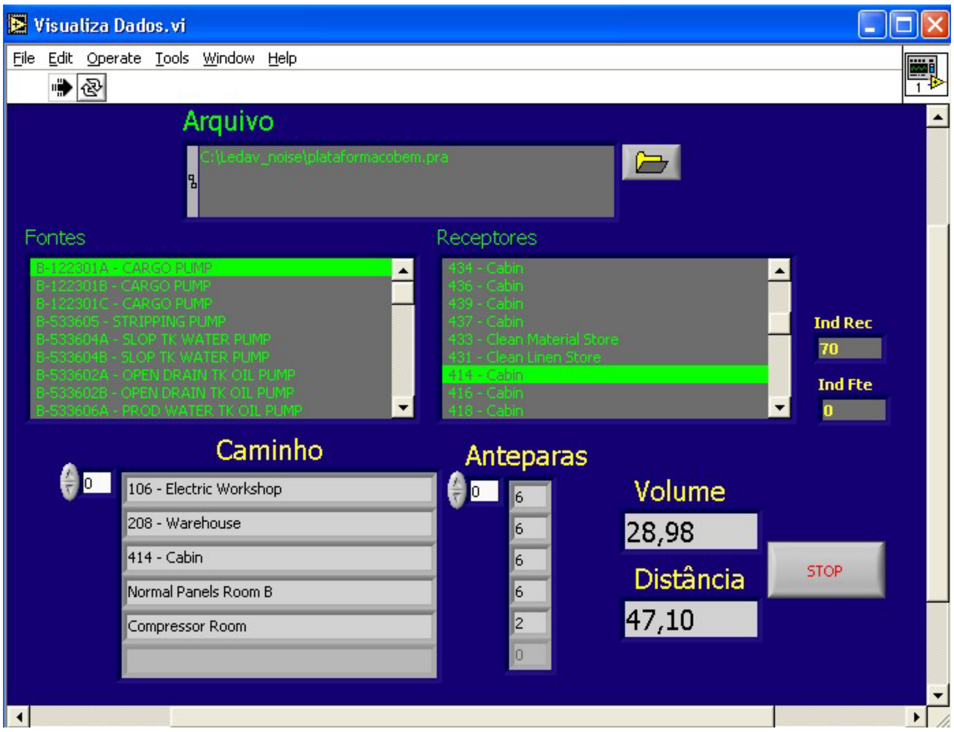
$$T.L. = 10\log\frac{1}{\tau} \quad (9)$$

Another parameter highly related to noise reduction caused by barriers or partitions is called Transmission Loss (T.L.). However, only transmission loss of materials, supplied by vendors, is not a fully appropriate parameter to be considered in noise predictions because it is receiving room acoustic properties dependent, as shown in (8). In general, transmission loss values presented in reference tables are obtained through test chamber in laboratories with the acoustic conditions of the test incorporated in it.

4. Airborne Noise Software

The case of ships and offshore platforms consists of a complex problem of several noise sources and several receptors. The barriers (figure 3b) represent deck, bulkheads and ceiling of the compartments. Noise, represented by straight lines between the sources and receptors,will act on certain compartment incidence surface before arriving to the final receptor compartment. Through this methodology, everything happens as if, at first, the points A and B were in free field (Fig (3a)). However some elements were added to the system (Fig. (3B)) and the consequent reduction of the noise level is represented by the total average insertion loss of these elements.

Figure 4 shows one screen of the path noise viewer software where the path used by noise from a source (pump) until the receptor (cabin) is presented. It can be observed that the noise reaches some surfaces of some compartments before arriving to its “target” determining the intersection of straight line and plans. Software establishes the paths between the points A (source) and B (receptor) in each case.



Arquivo: C:\Ledav_noise\plataformacobem.pra

Fontes:
- B-122301A - CARGO PUMP
- B-122301B - CARGO PUMP
- B-122301C - CARGO PUMP
- B-533605 - STRIPPING PUMP
- B-533604A - SLOP TK WATER PUMP
- B-533604B - SLOP TK WATER PUMP
- B-533602A - OPEN DRAIN TK OIL PUMP
- B-533602B - OPEN DRAIN TK OIL PUMP
- B-533606A - PROD WATER TK OIL PUMP

Receptores:
- 434 - Cabin
- 436 - Cabin
- 439 - Cabin
- 437 - Cabin
- 433 - Clean Material Store
- 431 - Clean Linen Store
- 414 - Cabin
- 416 - Cabin
- 418 - Cabin

Ind Rec: 70

Ind Fte: 0

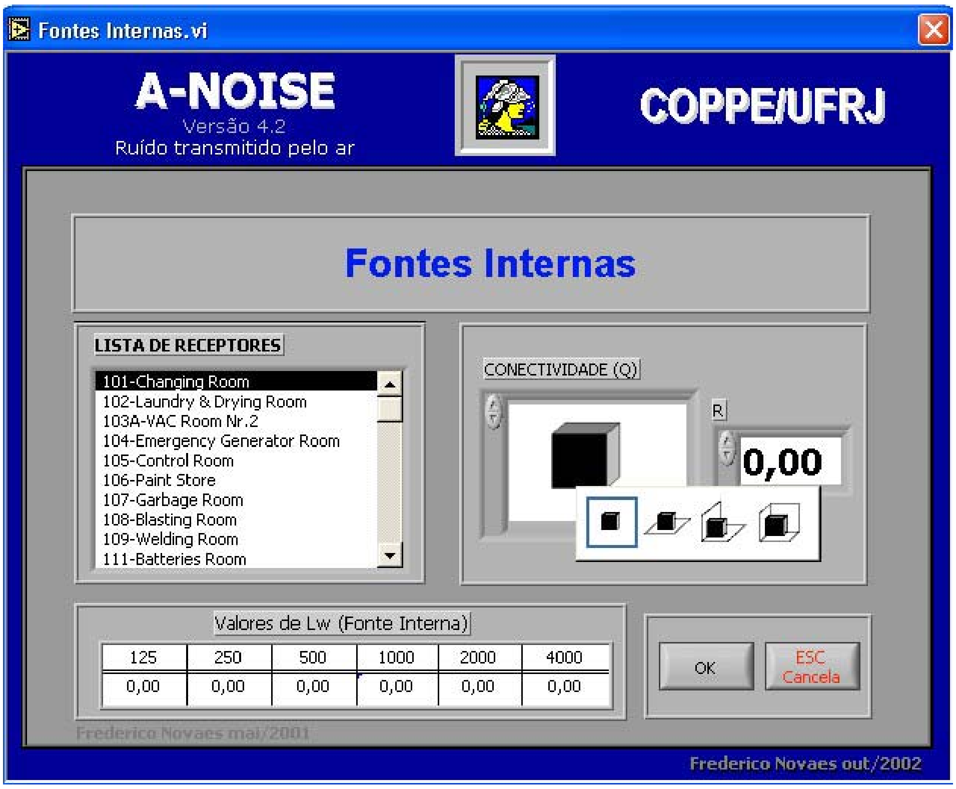
Caminho (0)	Anteparas (0)
106 - Electric Workshop	6
208 - Warehouse	6
414 - Cabin	6
Normal Panels Room B	6
Compressor Room	2
	0

Volume: 28,98

Distância: 47,10

Figure 4: Noise Path Viewer

Frequently noise sources inside compartments have an intermittent operation. However these sources are very important in noise prediction. Laundries, Emergency generator rooms and VAC rooms are some compartment where internal sound pressure level is strongly influenced by internal sources. In these cases, noise power, room absorption properties (room constant) and noise directivity are included in calculation. A-Noise software is able to consider internal noise sources as illustrated in Fig. 5.



LISTA DE RECEPTORES

- 101-Changing Room
- 102-Laundry & Drying Room
- 103A-VAC Room Nr.2
- 104-Emergency Generator Room
- 105-Control Room
- 106-Paint Store
- 107-Garbage Room
- 108-Blasting Room
- 109-Welding Room
- 111-Batteries Room

CONECTIVIDADE (Q)

R 0,00

Valores de Lw (Fonte Interna)

125	250	500	1000	2000	4000
0,00	0,00	0,00	0,00	0,00	0,00

Figure 5: Internal Noise Sources Input

5. HVAC System Noise

In agreement with Fischer et al, “A proper acoustical environment is as important for human comfort as other environmental factors controlled by air-conditioning systems. The objective of sound control is to achieve an appropriate sound level for all activities and people involved, not the lowest possible level. Because of the wide range of activities and privacy requirements, appropriate acoustical design levels may vary considerable from room to room”. The same reference also establishes “HVAC systems require energy to do work, and inevitably some of this energy converts to acoustic energy as well as mechanical energy”.

Crewmembers of ships and platforms reports and experiences of previous predictions have showed the importance of the HVAC system noise on the total ambient noise. There are cases in that the worker prefers the thermal discomfort to stay exposed to a permanent ventilation noise.

The proximity between the fans and receptor spaces (short ducts), the geometric configuration of the ventilation ducts and the presence of the fans inside or near the accommodation areas can be pointed as main factors that does the HVAC System noise an important element for the acoustic problem. The design of an HVAC system is an engineering balance between space limitations, noise considerations, initial cost and operating cost.

The noise generated by HVAC systems can be treated similarly to any other noise problem, consisting of the analysis of source, transmission path and receiving space. While each element appears to be independent, they can, jointly or individually, affect the prediction results significantly. As such, the understanding of each element, and particularly the input data required, is essential before proceeding with the calculation. Specifically in this case, in view of a propagation confined in ducts, it is important to consider the noise directionality, involving the phenomena of reflection, absorption and sonorous transmission, where, according to Fischer (1983), the three main attenuation mechanisms are:

a) Absorption of the acoustic energy at the interior surfaces of ducts, at turns and by silencers;
b) Division of sound and flow in branches (tee type ramification);
c) Reflection of sound back toward the source at turns, openings, and other path discontinuities, such as plenum and mixing boxes.

Thus, calculation of HVAC noise depends on knowledge of the sound power output of the fans in the air conditioning system. The noise emitted from air outlets in the receiving space will depend on the amount of noise attenuation due to the length of ducting, types of duct branches, air flow rates and the characteristics of any silencers fitted. The resultant sound pressure level in the space is then calculated, taking into account the acoustic properties of the space itself. Four noise attenuation components can be considered:

1. Attenuation for duct length: It refers to noise reduction in the straight portion of the ducts, and depends on the section shape (circular or rectangular), the material of the wall interns (lined or unlined) and the characteristic dimension of the section.
2. Attenuation for turns: It occurs whenever the noise is submitted to minimum direction changes of 30° that induce the sound wave reflection propagation towards the flow direction. The reflected wave interferes with the incident wave in a cancel manner, reducing the noise strength.
3. Attenuation for branches: This type occurs whenever the noise is radiated by tee or crossing intersections, being directly proportional to the area variation before and after the intersection point.
4. Attenuation for end reflection: In the duct terminal ports, the noise meets a severe variation of area, causing a sound reflection that acts under an attenuation form of the forward sound wave, reducing the low frequency amplitudes significantly. However, this only happens when a straight section of length 3 to 5 times the duct diameter precedes the end reflection.

The general methodology consists of calculating the sound attenuation due to each path element type (turns, branches, end reflections, etc), adding them to obtain the total transmission path for a particular duct. This analysis is performed in octave band frequency. It should be considered the sound power level of the source and the subtraction of the total attenuation due to the ducts.

In HVAC systems, the fan is the main source of noise. It must be selected in accordance to the airflow rate and to the total pressure of the system. In reference manuals, it is possible to obtain its noise power level base, which will be corrected by factors that depend on the fan speed.

In fact, the noise level in each room will be determined by the subtraction of the total attenuation through the transmission path from the noise level of the source. However, the actual noise level is influenced by other factors such as the receiver environment volume, and the area and type of the materials used on walls, floor and ceiling, that determine the absorption coefficient, which affect the amplitudes of the waves reflected inside the environment. Figure 6 shows input format for HVAC system in A Noise software.

Ventiladores: VE5225

Diâmetro (pol): 0,00

Duto 1/1

Receptores:
101-Changing Room
102-Laundry & Drying Roo
103A-VAC Room Nr.2
104-Emergency Generator
105-Control Room
106-Paint Store
107-Garbage Room
108-Blasting Room
109-Welding Room
111-Batteries Room
112-Batteries Charge Roor
113-Essentials Panels Roor
115-Clean Mat Store Nr. 1
117-Safety Store
118-Nautical Store
119-CO2 Room

Figure 6: HVAC System noise data

6. Structure Borne Noise

The propagation of vibratory energy (or noise) through the structure is called structure borne (SBN).

Structure borne is sometimes recognized to be the major cause of noise problems in offshore structures: it is able to propagate through the steel structure, contributing predominantly to the noise level inside compartments that are far away from the sources. Therefore, SBN has been the object of most attention on ship noise analysis. The reduction of structure borne noise is mainly achieved through the process of diversification of energy at structural discontinuities rather than distance from the source. This explains why it is the main cause of noise levels in spaces remote from excitation sources.

When undertaking a SBN analysis, three major aspects have to be considered:

1. The interaction between machinery and the structure;
2. The transmission through the steel structure;
3. The interaction between the vibrating structure (plates, reinforced panels, shells, etc., usually existent in offshore structures) and the adjacent media (noise radiated to the sea and into the compartments).

From the three aspects mentioned above, the third is the one that appears to offer the least problems. The structure is the link between the sources and the media.

Power flow represents the rate of work carried out or the rate of energy supplied to a system. The vibrating power transmitted through structural components is dissipated by damping, transformed into heat and irradiated as sound energy, causing, sometimes, undesirable levels of vibration and noise. Therefore, it is essential to know vibrating power propagation mechanisms and energy transmission paths to the analysis, diagnosis and control.

Vibratory energy travels through structures in several waveforms types, as bending, longitudinal and torsional. Of all the types of waveforms considered, bending waves are the most important for structure borne transmission, as they are found coupled to the radiation of airborne noise. Noise radiated from a structure in an adjacent media is primarily caused by its flexural (bending) motions. However, this does not necessarily mean that bending waves carry more vibratory energy than other types of waveforms.

Aside from flexural motions, other kinds of motions may be important in offshore structures SBN analysis, because:

1. They can be induced in the structure. As a result of the machinery-foundation interaction, the power can be transmitted in the other waveforms through the ship structure.
2. Motion transformations can occur at the different structural discontinuities of the ship causing wave transformation into other wave type, and vice-versa. For example, if a two-beamed structure in relation to a right angle (in "L" shape) is transversely excited in the plan defined by beams, or longitudinally in the extremity of one of the beams, coupled bending and longitudinal waves are generated in both of them. But, if the excitation acts in orthogonal way to the plan defined by beams, coupled bending and torsional waves are generated.

Longitudinal motions can, in principle, radiate sound because of the cross sectional alterations associated with them. When the adjacent media is water, the power radiated by longitudinal motions may have some significance. However, when the surrounding fluid is air, the radiated sound is comparatively much smaller than the power radiated by bending unless the longitudinal energy level is very high.

The method by which energy is distributed in the process is still uncertain. This uncertainty is compounded when considering a complicated built-up ship structure with a large number of discontinuities, where many types of transmission mechanisms and paths, involving different kinds of energy propagation will be found. In such a situation, approximations in a theoretical assessment of the vibrational characteristics have to be made. Two important aspects have to be considered: (1) How to model the structure, and (2) What are its predominant motions.

Any method has its limitations and its strengths, but it is hard to believe that a particular approach could give all the answers needed for a complex problem such as noise transmission on offshore structures. When selecting an approach, several aspects have to be taken into account: it is essential that answers and results be given during the early design phases with the necessary accuracy and confidence, compatible with the available data and the cost constraints. The ability to explain existing problems and give support to recommendations for improvement is also very important.

7. Noise Predictions Methods

In the last fifty years, a number of noise prediction and analysis techniques have been developed. Among the approaches known, the following four can be mentioned: Finite Element Method (FEM), Boundary Element Method (BEM), Statistical Energy Analysis (SEA) and semi-empirical methods. The first three approaches aim to address the propagation of structure borne noise through the structural elements, from theoretical standpoints. In particular, the first two are jointly used in sound problems interacting vibrating structures and the surrounding fluid environment.

a) Finite Element Method:

This method together with other techniques that are applied on the domain is a kind of "domain" method. FEM technique discretizes the domain of a complex structure under consideration into a finite number of elements. The governing equations of the problem are then approximated over the region by functions that fully or partially satisfy the boundary conditions. Structural relationships can then be derived for each finite element, which link force and displacement components at the nodal points. Although the great strength of the FEM is its versatility, as there is virtually no limit to the type of structure that can be analyzed, the competence required to select suitable elements in building up the model can be gained through research work and/or practical experience. Technically, providing the element types are suitable selected, an increase in the number of elements will give better results. However, the use of more elements implies longer computing time and, as such, a balance has to be drawn between these two conflicting criteria. Experience gathered in the past suggests that FEM is particularly suitable for problems concerning low frequency vibrations.

b) Boundary Element Method:

While Finite Element Method (FEM) arises in the middle of the decade of 1950, the first book on the Boundary Element Method (BEM) was published in 1978. Initially, the methods of solution of boundary integral equations were physicist and mathematicians' exclusive domain. Later it was noticed that the advantages offered by this class of methods could be useful in the solution of engineering problems.

Potential problems, those that can be described as function of a potential, constitute the typical BEM applications. Examples as systems of cathode protection for ships and offshore platforms in which, by FEM, it would be necessary not only modeling of the structure but exhausting modeling of the sea water can be more easily treated by BEM since only the boundary of the problem needs to be modeled.

However, if BEM introduces a series of advantages to the solution of problems of noise radiation, difficulties still exist to overcome its application in some classes of problems. This fact has been motivating several authors along the years propose alternative methods or simply techniques that allow the application of Boundary Elements at several cases for obtaining of necessary results within a reasonable computer time.

c) Statistical Energy Analysis:

SEA deals with coupled systems and power balance equations are used to estimate the energy level of the different systems. The primary variable is energy and the input is the power delivered to the systems by external sources. A fundamental point is the definition of a SEA system: "a group of similar resonant modes of a given nature". SEA systems are not structural elements, but are directly associated with the motions that can be induced in these elements.

The method involves the evaluation of vibration energy dissipated between connected resonant structures by a statistical method, and is based on the assumption that the flow of vibrational or acoustical energy between two subsystems is proportional to the difference in energy levels between these sub-systems, the coefficients of proportionality being the loss factors. Two types of loss factors can be identified: 1. Loss factor: associated with the power dissipated by the system; 2. Coupling loss factor: associated with the power lost by a system to another coupled to it (power flow between systems). The major conditions under which SEA can be applied are that the coupled systems are resonant and that the modal density (the number of resonant vibration modes within a frequency bandwidth) of each system is sufficiently high. The higher the number of mode shapes that appear in each system, the better is the accuracy. The method generally provides fairly good results at high frequency bands but not in the low frequency bands.

d) Semi-empirical approaches:

The approach uses existing well-developed empirical formulae to calculate airborne and structure borne noise attenuation that are based on measurements and data taken on board ships, but the accuracy of the results will ultimately be determined by the quality of the input data. In general, expected energy levels at various ship locations are estimated by using attenuation factors or transmission losses along structural discontinuities. Probably this is still the most commonly adopted method for noise prediction.

The input data could be obtained from various sources. With respect to noise source data, manufacturers are usually able to supply noise data associated with the machinery supplied, in terms of both airborne and structure borne noise levels. Even without this information, however, data can be interpolated from noise measurements on similar machinery, or even calculated approximately from empirical formulae. Regarding the data from the receiver, the acoustical properties of the structure are normally well determined either by laboratory tests or site measurements. The characteristics of the transmission path present the most problems in terms of the calculation of structure borne noise attenuation.

Some considerations are important and should be mentioned:

1. FEM and SEA are completely general: FEM has been used extensively for ship structural analysis and optimization at more detailed design phases. The power of FEM for modal analysis is undoubted, particularly when considering that the junctions between structural elements and boundary conditions can be efficiently and explicitly represented.
2. FEM and BEM can also be combined to obtain a better representation of the boundary conditions in a finite element program. Finite elements results may, for instance, be very inaccurate due to the difficulty of representing properly the boundary conditions in problems such as those with infinite domains. For these problems it is possible to propose a sub-division of the region of interest into finite elements and to use boundary elements to better approximate boundary conditions such as radiation. (The boundary elements represent the boundary between the finite element region and the infinite domain).
3. The definition of SEA subsystems as a group of similar resonant modes of a given nature (flexural, torsional, etc) makes its modeling principles suitable to include, without a physical restriction, the different kinds of motions that are possible to be induced in the ship's structural elements. The energy transmission mechanisms and energy conversions can then be understood as sharing and flowing between the coupled mode groups.
4. If the motion of a mechanical noise surface source, such as a vibrating plate, can be described as a velocity field, then, in principle, it is possible to determine the pressure field generated by this source, as well as the power radiated. The traditional approach Modal Analysis can be used to determine the velocity response of the structure of interest, being necessary to specify the source of excitation and the structural dynamic characteristics, and to know the mode shapes of interest and the corresponding resonance frequencies, which can be determined, for a complex structure, by means of FEM, and also the associated modal damping loss

factor. This approach is time consuming, complex and costly, especially when sensitivity analyses are necessary, requiring the knowledge of structural details that are not available at the earlier design phases and is usually limited to low frequencies.

5. When adopting an energy approach, it is necessary to analyze how much power (or energy) is delivered by the machinery to its foundation, and how much of this power reaches the compartment's boundary or structural section of interest. The answer for the second question is intimately related to the transmission mechanisms and to the energy paths along the structure and associated attenuating and dissipative effects.
6. The power dissipated by the structure and the power radiated to the media are evaluated by determining the energy level of the structure and its loss factor, together with the concept of power or energy decay on its way through the structure. Wave propagation is adopted, and the dissipation factor included in the wave number.
7. Another attractive aspect of SEA is the simplicity of its power balance equations, demanding little computational work, handled by library programs developed for solving systems of linear equations. Being a statistical approach, SEA gives statistical answers and, therefore, offers an inherent degree of uncertainty. This can be regarded either as an advantage or as a disadvantage. Combined with the simplicity factor, this is very important to the design phases, when the details of the ship are not yet defined. In these phases, trade-off, comparative and sensitivity analyses are often carried out and compliance with limiting or upper bound specifications or levels is continuously verified. In this situation, approximate results are often satisfactory and can be utilized as guidance and as an indication that a more accurate analysis or more detailed information is essential. As more data becomes available and is used, better results are obtained.
8. Another aspect that has to be emphasized is that an absolute number is not always the necessary answer. The understanding, identification and interpretation of a problem and the determination of a line of action may be essential to support a decision on a ship design phase or in the analysis of an existing ship problem, and SEA may be suitable for this purpose.

8. Conclusion

Over years it became common to affirm that the airborne noise would be dominant in machinery areas while the structure borne noise would be dominant in accommodation or living quarters areas. Nowadays, this generalization needs to be revised considering that many machines are equipped with Anti Vibration Mounting (AVM) and some VAC Rooms are placed in accommodation areas, simultaneously increasing the influence of airborne noise and reducing the influence of structure borne noise in these areas, for instance.

HVAC system noise reduction is duct layout dependent. Some cases in which, the system assists near VAC rooms and far away areas simultaneously, due to flow requirements, it is possible the occurrence of noise problems in more approximate supplied rooms.

Numeric methods applications such as BEM and FEM are not still sufficiently safe due to the complexity of the problem that involves several noise sources and receiving spaces.

Trying to understand the analysis limitations is of fundamental importance for the best use of the acoustic prediction advantages. The noise prediction should be used preferentially as an important tool of sensibility analysis. One should not wait for full agreement between measured values and predicted values because the prediction is based on empiric formulas and many assumptions are involved, such as:

1. Noise Power Levels (NWS) data, supplied by machinery manufacturers, are approximate values;
2. Transmission Loss (T.L.) data, supplied by material insulation manufacturers, are approximate values;
3. In some cases, transmission path between Noise Source and Receptor is complex and it is very difficult to be implemented in noise software;
4. Internal Noise Sources, washer machinery and emergency diesel generator, for example, change global noise level, in intermittent operation;

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