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PREDICTION OF NOISE LEVELS ON OFFSHORE INSTALLATIONS

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1. INTRODUCTION

The consideration of noise has always been important on offshore oil and gas production platforms and drilling rigs due to the high density of powerful equipment and their close proximity to sensitive receiver areas (eg sleeping quarters).

Although airborne noise problems have been considered in some detail in contemporary literature, the specific problems of structure-borne noise are rarely addressed. This paper sets forward where, it is believed, there is a need for measurement studies to assist in the formulation of a simple structure-borne prediction method.

A separate issue is the assessment of operator noise exposure levels offshore, where airborne levels tend to dominate. Area noise limits offshore are defined by the Department of Energy in their Guidance Notes (Ref. 1) but there are no specific guidelines on how to appraise operator noise exposure levels. Thus although the Noise at Work Regulations (Ref. 2) have no legal applicability offshore, platform operators are increasingly taking heed of this guidance, which has been set forward by The Health and Safety Executive, and using this as a tool to help prioritise areas where noise control should be implemented. This paper discusses some of the problems associated with estimating operator noise exposure levels.

2. NOISE CRITERIA

The noise criteria for offshore platforms and rigs are set forward in the Department of Energy manual 'Offshore Installations: Guidance on Design, Construction and Certification' (Ref. 1).

This document sets forward target design noise levels not only for the noisy production areas (88 dB(A), but also quieter work areas such as control rooms and laboratories which have a 55 dB(A) limit. The rest/sleeping areas within an accommodation module have an even lower limit of 45 dB(A).

The (maximum) target work area noise criterion cited above of 88 dB(A) was originally set to take into account the working patterns peculiar to offshore installations -typically 2 weeks continuous working at 12 hours per day with then a subsequent 2 week break. It was intended to equate to a noise level of 90 dB(A) over an 8 hour day. This level can therefore be regarded as equivalent to the second action level under the 'Noise at Work Regulations' (Ref 2) if personnel are exposed to the maximum target level continuously during their 12 hour working shift. Similarly a noise level of 83 dB(A) may be regarded as the equivalent of the first action level.

But these levels are simply target design levels which, if met throughout the platform, would ensure that daily noise exposure levels (the $L_{EP,d}$ values cited in the 'Noise at Work Regulations') of all operators were below the relevant action level irrespective of work pattern.

In practice, of course, noise levels do not meet the (maximum) target levels of 83 / 88 dB(A) in all areas and hence operator work patterns are of great importance. This matter is discussed further in section 4.

3. NOISE LEVEL PREDICTIONS

Airborne noise levels can readily be evaluated in the main production / drilling areas, as well as in the accommodation areas, by recourse to the conventional guidance set forward in the UEG document 'Noise and Vibration Control Offshore' (Ref. 3).

However, in the case of structure-borne noise, there is a severe lack of knowledge on structural attenuation rates which can be used in 'up-front' design studies.

For ships' structures there are empirical formulae which set forward structural attenuation rates based upon the number of frames between source and receiver - with a similar correction also applied for the number of decks between source and receiver - see for example Refs. 4 and 5. In the case of a ships' structure, there is a relatively standard construction in that frames are invariably separated by a fixed spacing of 600mm. However, there is no standard construction arrangement for offshore structures which comprise primary and secondary steelwork of varying sizes. The primary steelwork members bound areas which contain deck plate overlay supported by means of supplementary (secondary) steelwork which may range from small bulb flat stiffeners to substantial I - beams.

The structural attenuation rate is governed by a number of variables including:

(i) size and separation of primary steelwork members perpendicular to the direction of vibration transmission;
(ii) size and separation of secondary steelwork members;
(iii) orientation of the secondary steelwork members ie parallel or perpendicular to the direction of vibration transmission; and
(iv) deck plate thickness.

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Although statistical energy analysis (SEA) models may be developed which would give a reasonable indication of attenuation rate for a given form of structural construction, such an approach is time consuming - particularly for design contractors. It is considered that what is missing from current design practice is an empirical calculation procedure for structure-borne noise.

It is suggested that the test programme could involve two parallel lines of approach, namely:

i) Measurement studies on operating platforms / rigs where the major vibratory tonal sources (such as diesels, mud pumps etc) are investigated by undertaking simultaneous vibration measurements at various distances from these sets to determine overall attenuation rates at specific tonal frequencies - for the given construction arrangements: and

ii) more controlled tests on a module structure which is fully fitted out, but prior to barging offshore. In this case the vibration input force and frequency can be controlled by use of a large shaker system driven by chirp excitation - to enable the investigation of transmission characteristics over broader bands of vibrational energy.

The former case has the merit that there is then a database of information not only on vibration attenuation rates but also source strengths: it has, however, the disadvantage that background vibration levels may well be high in some areas due to various other offshore activities, which could limit the range over which the tests can be conducted.

As discussed above, in addition to structural attenuation rates, it is also important to establish in any structure-borne assessment, how well coupled the source / receiver is to the structural support members. For example the method of mounting machinery (ie skid welded to deck / skid shimmed or chocked from the deck at discrete points / skid mounted on 3 point gimbals) and indeed use of anti-vibration mounts, all have a significant bearing on the efficiency of vibration coupling. Similarly, at the receiver location, the support arrangement of the living quarters (for example) has a significant impact on the structurally transmitted vibration. If, for example, the living quarters are integral with the primary structural steelwork, then the loss mechanisms at the support interface are minimised: but where the living quarters is mounted on a number of discrete mounting points then there is a significant mechanical impedance mismatch at each which leads to an enhanced discrete loss.

This can be observed historically by comparing the incidence of structure-borne noise problems on drilling rigs and offshore platforms; in the former case structure-borne noise problems abound - often created by vibration transmitted into the structurally integral living quarters from solidly mounted drilling diesel generator sets and mud pumps and from flanking airborne originated paths; in the latter case structure-borne noise problems are far less frequent - despite the presence of higher power rating equipment in close proximity to the living quarters - as the accommodation modules are often on discrete supports eg 4 point mounted.

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In recent years the trend on fixed offshore platforms has been to move away from mounting living quarters themselves on anti-vibration mounts (AVMs). This may have been in part due to general changes in the mounting of major machinery on three point gimbals or AVMs - both of which can readily accommodate deck distortion. Alternatively it may have arisen due to the ineffectiveness of some of the earlier accommodation module AVM installations due to mechanical short circuiting via stairwells / service connection etc.

4. OPERATOR NOISE EXPOSURE LEVEL PREDICTION / MEASUREMENT

Returning to the aspect of airborne noise the actual operator noise exposure levels which arise in practice are a function of several different parameters including:

(i) the work pattern;
(ii) the spatial variation of noise in each area visited;
(iii) the temporal variation of noise in area visited; and
(iv) the use of hearing protection.

although the latter item is not accounted for in estimating $L_{EP,d}$ values (under the Noise at Work Regulations) as there is no certainty that hearing protection will remain in regular use.

Estimating daily noise exposure levels in an offshore environment is fraught with problems as:

(i) many operator work patterns are extremely variable - for example maintenance personnel may be carrying out the overhaul of a machine which is directly adjacent to a noisy unit one day, and may be required to carry out work in a quiet area the next day;

(ii)* noise levels in a given module will vary throughout - this means that even if it is known, from log sheets that an operator has been located in a given area for a given period of time, the precise fractional noise exposure is still difficult to calculate;

(iii) noise levels in some modules also vary with time due to process variations, the number of machines in use, and machine operating speeds (eg mud pump stroke rate);

(iv) the effectiveness of hearing protection can be influenced by the fit of the device - for example the insertion loss performance of ear defenders can be reduced by some 3 - 7 dB (see Refs. 6 and 7) when personnel are wearing spectacles: this is particularly important offshore where safety glasses are used extensively.

Of the many variables the one described in item (ii) above is probably the most important as, even in modules, a noise level variation of 10 dB(A) is not unusual (although less than typical open air process plants). When viewed in terms of the equivalent exposure time variations this would correspond to the exposure period being scaled by a factor of 10. Thus if an operator was in practice exposed to an equivalent continuous noise level of 95 dB(A) rather than 85 dB(A) then, for the same fractional noise dose, his exposure period would need to be reduced by a factor of 10.

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When offshore measurements have been taken, attempts have been made to counteract this sensitivity by monitoring L_{Aeq} noise levels spatially throughout the module over reasonably long time periods and by spending significant periods of time at "fixed" operator stations (eg by control panels).

A broad assessment can then be made of expected operator noise exposure levels by producing a matrix of time versus module area and summating the fractional noise doses in each area separately (spreadsheet model).

However it is considered that the best method of approaching an operator noise exposure study is on two fronts:

(i) by undertaking relatively long term noise dosimetry assessments - preferably using dosimeters in which the noise profile can be downloaded and interrogated via support software - to establish which areas dominate the operator noise exposure level. (NB. It is still necessary for each operator to fill in a log sheet to establish the time spent in specific areas); and

(ii) by developing a simple spreadsheet program whereby noise levels and exposure periods are combined for each area yielding fractional noise doses which are then combined to give overall noise exposure levels for all operators at risk.

By separating out the measurement and desktop parts of the exercise, it is possible to identify separately the 'non-standard' noise exposure doses which can then be appraised independently (eg noise exposure during flaring, noise exposure levels associated with specific activities, such as welding or angle grinding etc).

Figure 1 sets forward a sample time history plot for a period of just under 4 hours taken from an offshore dosimetry survey. The data is taken at one minute intervals in two forms, namely

(1) the maximum (linear) peak noise level experienced within that one minute period (upper plot) and

(2) the L_{Aeq} value within that one minute period (lower plot).

This form of plotting presents a clear graphical time history of the noise which assists on two fronts:

i) it enables confirmation of actual times spent in high noise level areas - and the noise levels to which the operator was subjected during that time period; and

ii) it enables an appraisal to be made of which area occupancy cause the highest fractional noise dose - important when evaluating the cost effectiveness of a noise control programme.

This latter point is aided in part by the option available for some dosimeters, where the support software permits analysis of the energy distribution via appropriate graphical presentation.

An example of this output is presented in Figure 2 (which relates to the same noise - time history presented in Figure 1). Although this yields some additional information - in that it shows the range of noise levels which dominate the noise dose, ie 105 - 108 dB(A) and 116 - 118 dB(A), it is even more worthwhile to investigate fractional noise dose by area / operation. An example of this is when the time spent in an area with a given activity taking place (eg flaring) can be isolated and the impact of various 'what-if' scenarios investigated via the support software. This may take the form of investigating alternative noise control measures or the effect on overall noise exposure levels if operators wear hearing protection for just that noise exposure (eg whilst flaring or whilst in a given module etc).

5. CONCLUSIONS

This paper outlines some of the problems in appraising noise on offshore installations.

Structureborne noise problems tend to arise - although not exclusively - in the quieter platform areas (eg living quarters cabins, or in quiet work areas such as laboratories or control rooms). Although statistical energy analysis (SEA) software is available which permits the computation of structureborne noise, it is a time consuming process and not readily available to design contractors etc. It is therefore considered that there is the need for an empirical approach in which various different structural designs can be investigated to establish typical structural attenuation rates. This approach can then be used to eliminate / confirm the presence of problem areas, whilst accepting that SEA techniques will be of great value in the 'grey areas' between.

In the second part of the paper the very different problem of estimating realistic operator noise exposure levels is discussed, along with reasons as to why measurement (dosimetry) studies should go 'hand-in-hand' with desktop (spreadsheet) type studies.

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REFERENCES

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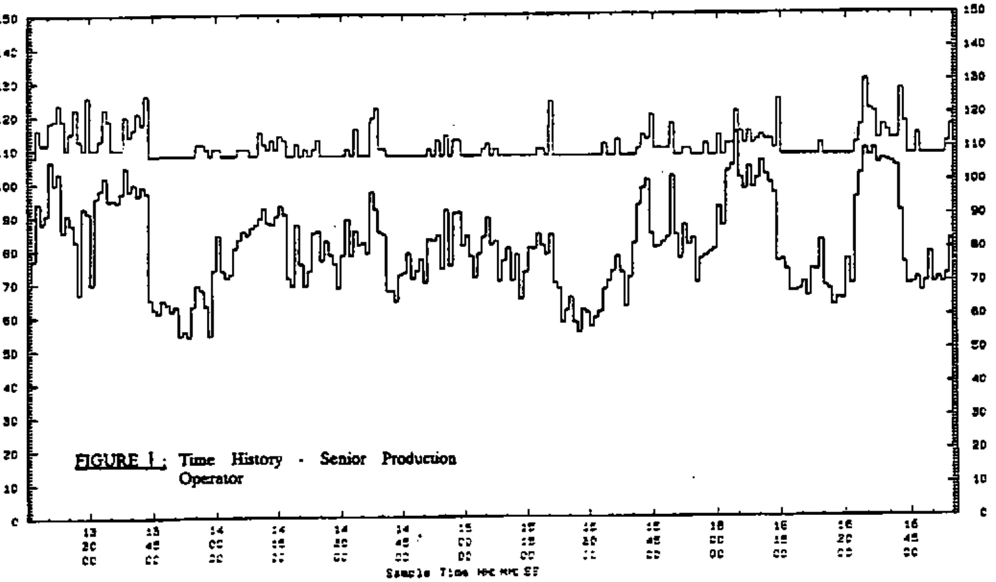

FIGURE 1 : Time History - Senior Production Operator

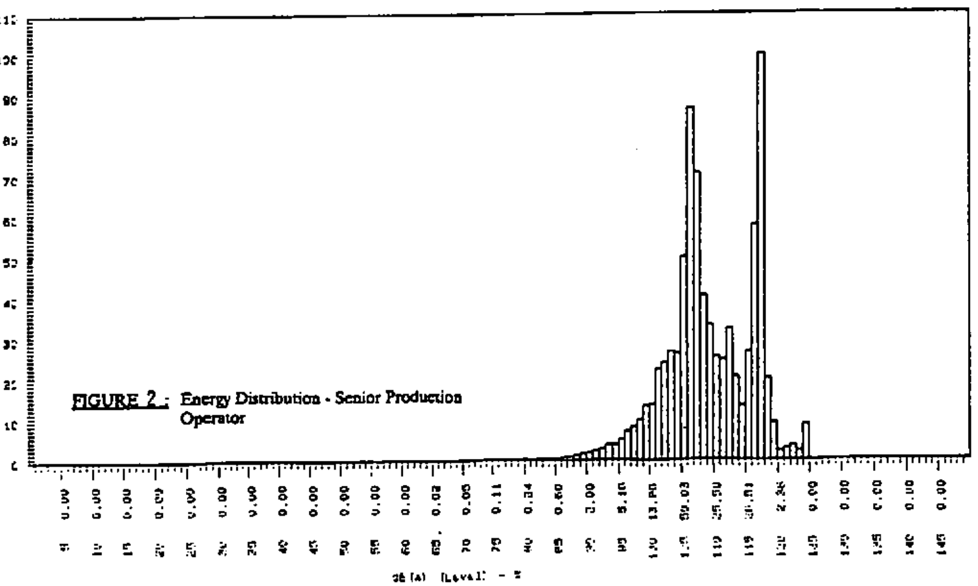

FIGURE 2 : Energy Distribution - Senior Production Operator