Application of Acoustics “Off-Shore”

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Abstract:

When dealing with acoustics “Off-Shore”, an acoustics engineer is faced with a whole gambit of acoustic related situations to consider when commencing and during the processes of design or refurbishments.

“Off-Shore” covers oil and gas platforms and drilling ships.

Some of the works required “Off-Shore” is similar to “On-Shore” acoustics when applied to process plant design.

There are many areas of “Off-Shore” work that rarely occur “On-Shore”.
One finds that often many diverse challenges arise when having to consider, “Off-Shore” projects.

This paper looks at the range of factors and challenges facing the acoustics engineer when dealing with “Off-Shore” projects with the intension of supplying guidance as to what to consider if faced with “Off-Shore” works.

Introduction

‘My formula for success is rise early, work late and strike oil.’ (Paul Getty)

Off-Shore engineering fundamentally is concerned with off-shore platforms and drilling ships.

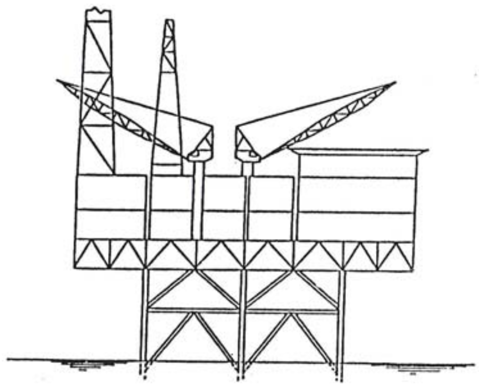
The main objective in both cases tends to be extract oil and gas.

The acoustics engineer’s involvement is to consider sound and vibration associated with the topside that can affect the personnel living and working off-shore.

Also to ensure that there are no equipment or piping failures due to induced sound and vibration.

There are two basic types of topside design and these are as follows:

- Modular Deck
- Hi-deck



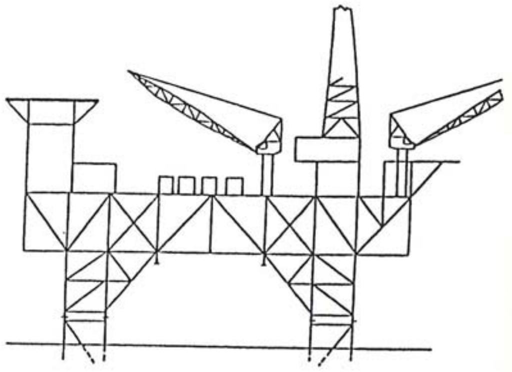


Image 1: Modular Deck Design **Image 2: Hi-Deck Design**

The difference in design is based on the total mass of the top sides which is major factor in off-shore design.

The Hi-deck design gives the lowest design mass and the Modular design tends to be significantly greater but is needed where onerous weather conditions prevail.

Off-shore platforms progressively increased in size as drilling depths increased.

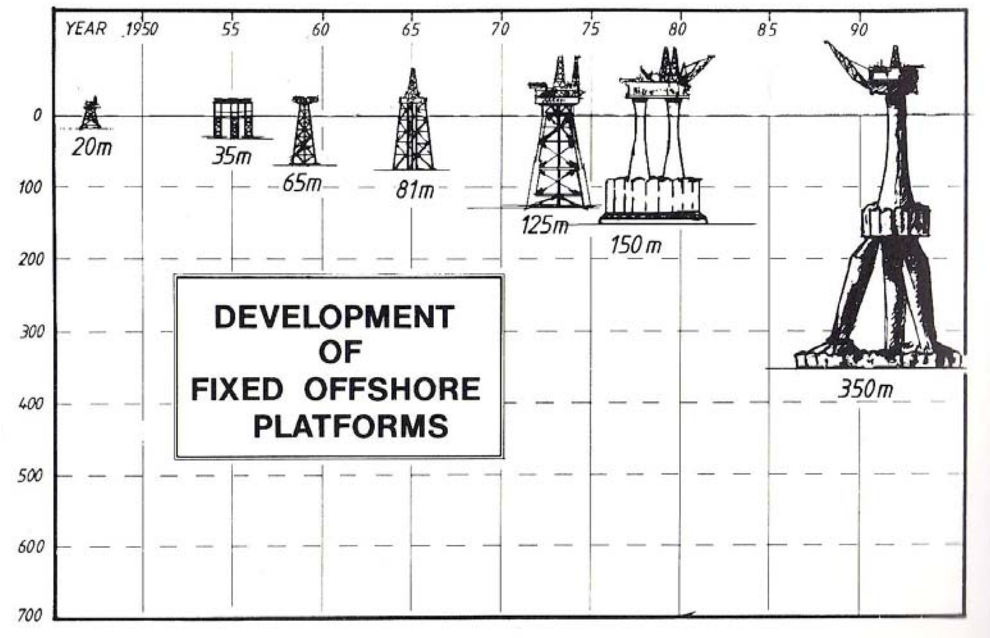


Image 3: General Development of Off-Shore Platforms over time

Often the off-shore design is influenced by the prevailing local meteorological and seismic conditions.

The following pictures show conditions in the springtime on the Molipak Oil platform in the Sea of Okhotsk Sea. One has to imagine the conditions in winter.

Picture 1a

Picture 1b

Picture 1c

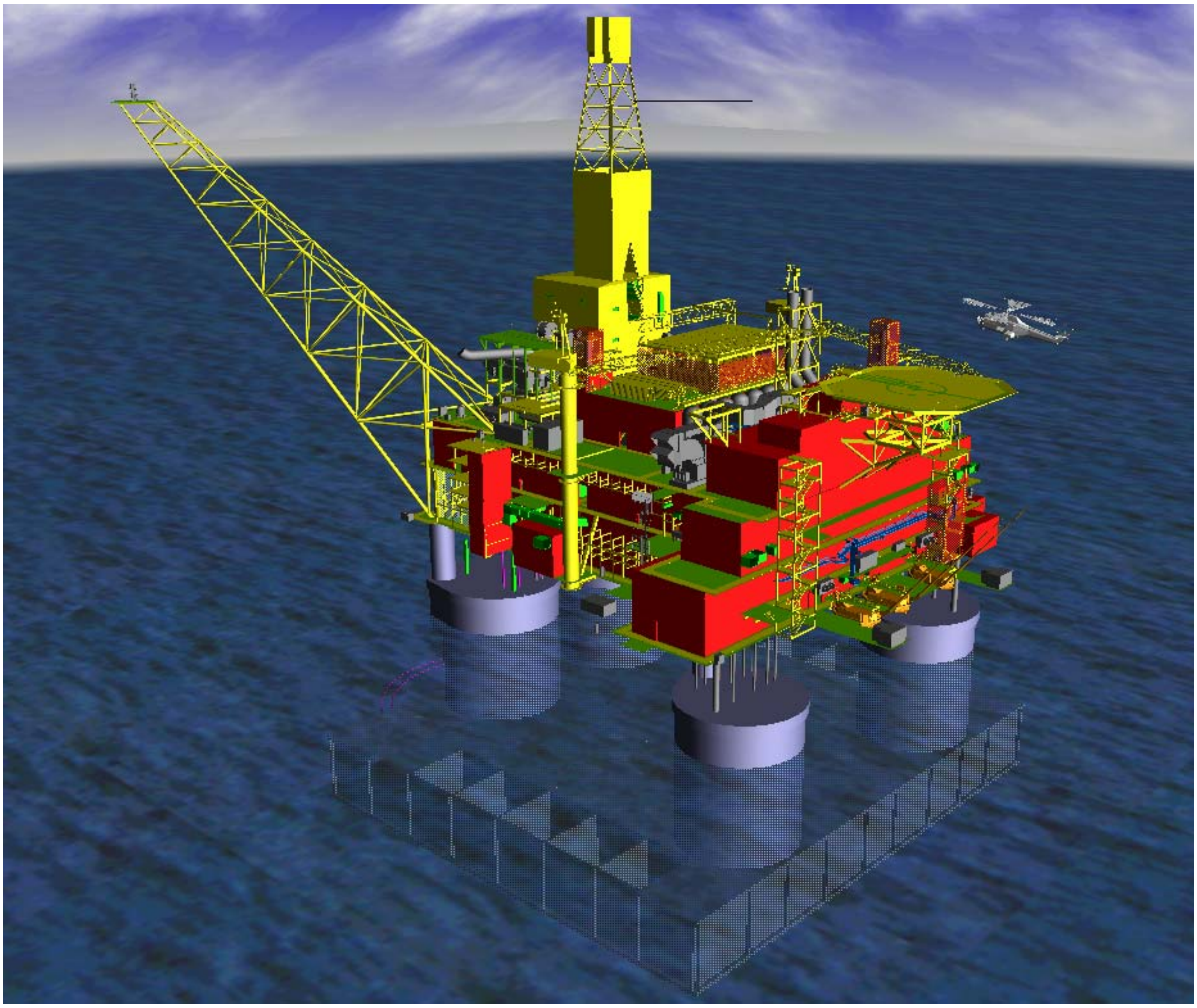
It can be seen that the increases in masses of equipment due to ice can be significant.

The use of external telephone booths would be pointless in winter.

The acoustic design involved is no different in many ways to that used for on-shore acoustics design but often included more onerous conditions.

The main difference in the acoustic design on-shore and off-shore lies in the fact that the mechanical equipment items will have to be supported on the topside structure in the case of off-shore design.

Picture 2; shows a computer model of a platform with modular deck design topside.



Picture 2: Computer modular designed topside

Acoustic Design & Advice

These are some of the areas where acoustic advice and design may be required:

- Vibration & isolation.
- Earthquake and shock predictions and protection measures.
- Communications masking.
- Alarms and warning systems.
- Sound levels produced by drilling equipment.
- HVAC systems.
- Active noise attenuation.
- Design of bespoke acoustic attenuators and enclosures.
- Reducing the risk of intelligibility in mustering areas.
- Drilling and under water sound.
- Bird scaring systems.
- Prediction helicopter sound levels.

The following is a list of the most common sources of sound to be considered when designing platform topsides.

Mechanical Equipment Used Off-Shore

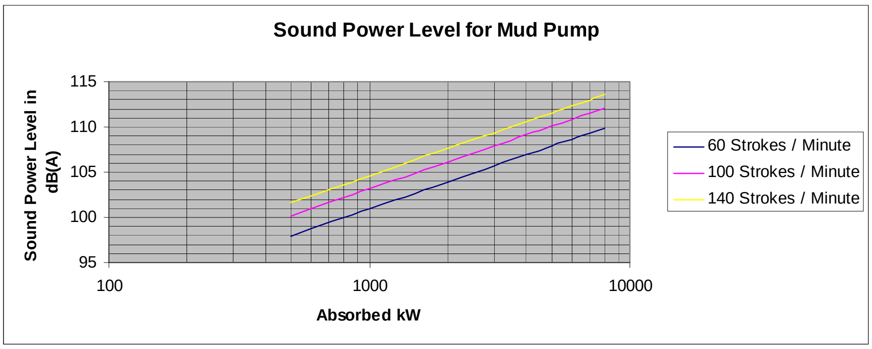
These are a few items of equipment utilized off-shore.

- Pumps
- Compressors
- Gas Turbines
- Diesel Generators
- Piping, Valves and Orifice Plates
- Flaring
- Draw works
- Cementation equipment
- Shale Shakers

The sound power level of each acoustically significant equipment item is predicted. The following typical prediction method is for a typical mud pump.

Mud Pump Sound Power Level Prediction

Picture 3: National Oilwell Ltd. Mud Pump



Graph 1: Sound Power Level

Graph 1; gives the overall sound power level in dB(A) and an octave band spectrum may be obtained by applying the following spectral corrections.

Octave Band Frequencies Hz.								
	63	125	250	500	1000	2000	4000	8000
Correction dB	-5	-1	0	-2	-4	-9	-16	-24

Table 1: Spectrum correction for Mud Pump sound level

Such Pumps are reciprocating and can vary in speed of operation.

Similar sound level predictions are used for all other equipment items such as Flaring, Gas Turbines, Centrifugal Pumps, Draw Works etc.

Sound Level Criteria

Sound and vibration level criteria are required to give a guidance of acceptability at locations throughout any platform topside.

Some common airborne sound level criteria which are set by various authorities are as follows:

83 dB(A) for general work areas / production and drilling.

70 dB(A) for workshops, general stores and food service facilities.

55 dB(A) for control rooms, general offices, radio communication rooms, dining rooms.

45 dB(A) for television rooms, meeting rooms, sleeping areas, libraries / quiet rooms.

There are also vibration acceleration limit criteria set.

Seismic loadings are also to be considered.

This paper has been prepared to give practicing acoustic engineers an idea of the difficulties these criteria presents with reference to the activities, types of mechanical equipment and the acoustic environment encountered offshore and their possible affects on the accommodation areas.

The question here is.

- Should a more complete practical guidance on criteria be considered for use with the off-shore industry?

- One that takes into account the types of activities undertaken during drilling and well clean-up operations for example?

The Acoustic Engineering Approach

Overall Understanding of the Offshore Operation

When considering the design of an offshore platform a decision has to be made regarding the accommodation

- Should the accommodation be a self-contained modular design?
- Should the accommodation be integrated into the topside structure?

This decision is based on the demands of the operations taking place and structural considerations.

The acoustics engineer has to work with the decision made.

The sources of sound energy encountered on an offshore platform can be divided into three groups.

- Sound energy produce by equipment and operations used in normal operations.
- Sound energy produced by equipment and operations used in abnormal operations.
- Sound energy generated due to the environment.

Design for Normal Operations

Normal operations are operations that would be expected in any normal process plant. This means sound power allocations plans have to be prepared for all plant-rooms on the platform.

Therefore based on the mechanical equipment list for the plant-room being considered the estimated sound power level for all acoustically significant equipment items needs to be predicted without acoustic measures.

Besides the mechanical equipment in any plant-room there will be piping and valves and also Heating & Ventilation (HVAC) equipment.

A predicted sound power level allowance has to be made for these in obtaining the estimated total sound power in the plant room.

This process is usually carried out for continually operating equipment this gives rise to the definition of continuously operating.

We adopt the following reasoning

If the sound power level produced by any item of equipment is 10dB less than the sound power level when the equipment item was running 100% of the time then the item of equipment would be considered operating non-continuously.

This sets a limit for any equipment item that is to be considered non-continuous of anything running less than 10% of the time.

This does not necessarily mean that non-continuous operating equipment should be ignored because the case exists where the equipment if particularly noisy in operation can produce sufficient sound energy in the 10% of the time that it is running that the dB(A) L_{eq} over the working time period could be acoustically significant in so far as acoustic measures may need to be applied.

The main question at this point is.

What is the total sound power level that can be allowed if the airborne sound pressure level criterion set for plant rooms is to be achieved?

This figure is of great significance and is achieved in the following way:

For a given plant room a 3D acoustic model is prepared that allows for the acoustic properties of the room. The plant rooms are essentially large steel boxes.

At this stage in a project the final location and size of machines may not be fixed but a suitable model can be produce by inputting sound power level estimates for the mechanical equipment, piping & valves and heating and ventilation.

The model gives the following outputs:

- A grid matrix of sound pressure levels in dB(A) across the room.
- A listing of all sources of sound in the room in descending order of magnitude of their contribution to the total overall sound pressure level at any specially selected receiver points in the room.

The use of the special receiver point data is that it allows decisions to be made regarding where acoustic measures need to be applied to achieve the criterion set.

It is often found that the sound pressure level across the plant rooms varies by only a couple of decibels this means that contour plot would be unnecessary and why the grid method is used.

This is sufficient information to establish the maximum total sound power level that will give the required sound pressure level in the plant room.

Having established this, the sound power level allocations can be made for all mechanical equipment items and sound level data sheets can be prepared for submission with equipment bids. Equipment sound power level either best estimate / guaranteed both with and without acoustic measures may be produced. This procedure has to be completed as fast as possible.

While awaiting the vendor data for the machinery the following is undertaken:

- Predictions sound power levels due to valves / orifice plates and associated pipe work and the selection of suitable pipe laggings to ensure the sound radiated from the pipe work is within the sound power allocation.

- Prediction of sound radiated from heating & ventilation equipment and the selection of suitable attenuation measures.

It is clear that the mechanical equipment items need to be isolated from the floors of the plant rooms, which are resilient.

If isolation is not provided then sound energy will be transmitted into the floor and will be then transmitted through the platform structure using any large surface areas as acoustic aerials to transmit airborne sound.

That is isolation mounts need to be provided which have been selected allowing for the resilient floor.

Flexible support structures such as floors, these floors acts as a springs.

On selecting an isolator to be placed between a machine and the floor and having selected an isolator with natural frequency way below the lowest frequency to be excited by the machine.

The natural frequency of the floor itself will be below this frequency.

Under these conditions low frequencies in the machine frame below 1.414 times the natural frequency of the machine mount will pass into the floor.

The floor is now being excited by frequencies near to its own resonant frequency. Although the forced transmitted may be small this is clearly undesirable.

To overcome this, the natural frequency of the isolator should be around half the natural frequency of the floor. Putting it another way the static defection of the isolator under the weight of the machine should be three or four times the deflection of the floor under the weight of the machine.

On many projects the structural engineers will have stiffened the floors where the machines will rest to minimise the isolator deflections.

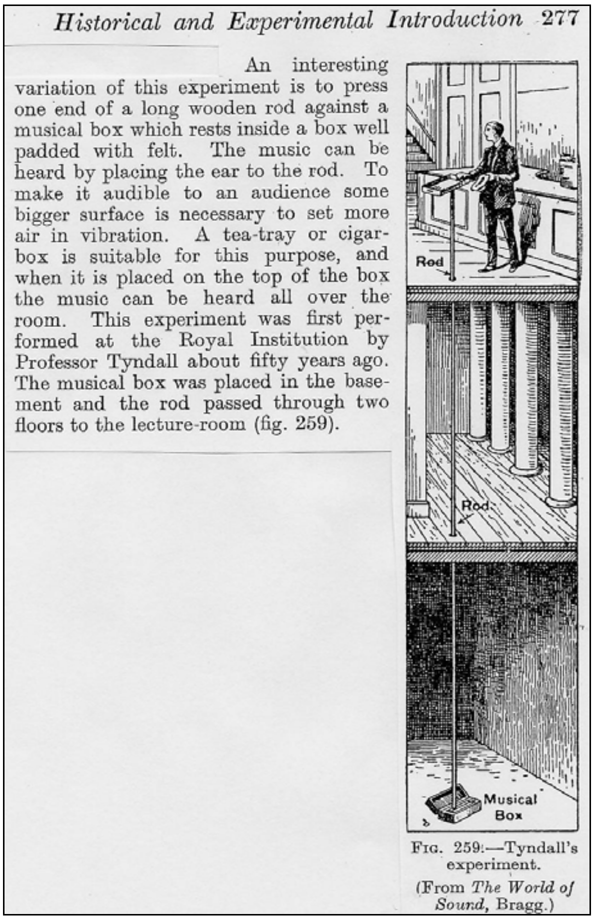
Therefore for the following reasons the inclusion of isolation mounts is important.

- To isolate sound from getting into and using the structural elements as acoustic aerials.

- To minimise sound energy passing into the accommodation especially where the accommodation is not of a modular design which would facilitate separate isolation

- To control acceleration levels to meet vibration criteria.

It has been the practice in the past on platforms to weld or bolt the machinery to the floors. The consequence of this being that any airborne sound level criteria will be exceeded even if, the sound pressure level at one meter from the items of machinery was correct as predicted by the vendors.



Historical and Experimental Introduction 277

An interesting variation of this experiment is to press one end of a long wooden rod against a musical box which rests inside a box well padded with felt. The music can be heard by placing the ear to the rod. To make it audible to an audience some bigger surface is necessary to set more air in vibration. A tea-tray or cigar-box is suitable for this purpose, and when it is placed on the top of the box the music can be heard all over the room. This experiment was first performed at the Royal Institution by Professor Tyndall about fifty years ago. The musical box was placed in the basement and the rod passed through two floors to the lecture-room (fig. 259).

FIG. 259:—Tyndall's experiment.
(From *The World of Sound*, Bragg.)

Picture 4:

The above illustration; **Picture 4**; shows a demonstration by Professor Tyndall at the Royal Institution showing how sound energy can pass through the smallest of direct connections and be amplified by a surface at the receiving end.

The Design for Acoustically Significant Operations

These operations tend mainly to be associated with the drilling operation.

These include the following items and operations:

- Mud Pumps.
- Cementation.
- Shale Shaking.
- Well clean-up operations including flaring.
- Draw-works operations including piling of conductors and intermittent drilling.

To indication the levels of vibration and sound produced by these equipment items and processes are as follows following:

These operations are not carried all the time but can last for months needed.

Mud Pumps

These are reciprocating pumps weighing typically 65 tonnes each and having a pumping rate of between 10 Hz. and 100 Hz. (See Picture 2.)

Cementation Plant

This normally runs when the mud pumps are not running and tends to be marginally noisier than the mud pumps.

Shale Shakers

This machinery has low power input but tends to be tonal at around 31 Hz.

Well Clean-up

The main source of sound here is flaring using boom radiating out from the corners of the platform. A sound level from these flares is typically 150 dB(A) sound power level. This can carry on intermittently for a few weeks.

Draw-works Piling

This is a system commonly driven by a one-cylinder diesel engine raising a larger hammer, which can range in weight typically between 16 tonnes to 64 tonnes.

This hammer system is raised and let fall around 50 times a minute for

20 minutes knocking conductor tubes into the seabed.

This is followed by 20 minutes of sound due to drilling to removing the material, which takes 20 minutes and then the draw-works starts over again.

This cycling procedure may go on for weeks

The forces involved here are great enough to be discerned as small shocks on the topside

Acoustic Check List

The acoustics engineer performing the acoustic design on off-shore platforms to meet ***'the spirit of the intention'*** of the sound level criteria being set.

They will need to consider the following:

- A 3D computer program to produce acoustic models ideally suited for the design of plant rooms is a basic tool required to do this design.
- To be aware of the limitations with regard to drilling operations.
- Ensure the inclusion of isolation mountings.
- Like any ordinary building any power plant will be located in its own rooms.
- Where abnormal operations take place ear defenders will need to be worn. The ear defenders chosen should be selected with care to suit the situation.
- They should be aware that ear defenders are not to be considered as an acoustic control measure and are suitable only for temporary use.
- Intelligibility needs careful consideration in areas used for mustering.
- Attention should be paid to areas where access can be made by personnel where venting can take place during upset / blow down conditions to ensure ear defender notices are in place.
  (Sudden high sound levels can be a shock.)

Final Comments

- The selection of criteria planned to be used for a project although commendable in their concern for the work force do not reflect the practical situation that occurs in the fundamental operation encountered on a drilling platform.
- More thought needs to be applied in setting criteria that are to be used.

- Some method is required of ascertaining if a reasonable amount of money has been spent on acoustic measures with reference to the cost of the project under consideration and other past projects.

  What we are saying is that any criteria can be achieved if you spend sufficient money (You can put a man on the moon if you have enough money.) but the off-shore platforms do have to be profitable and the limits of reasonable acoustic engineering design need to be considered when creating and setting sound level criteria.

- If the procedures discussed in this paper are adopted then we may say that the **'best practicable means'** will have been applied.