SOUND AND VIBRATION ANALYSIS FOR 70 M SUPPLY VESSEL IN ASPECT OF UNDERWATER NOISE REDUCTION

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The underwater noise and on-board noise measurement analysis, for 70 m supply ship, are presented in the paper, as well as the noise data for main machinery installed on-board. The results were completed by vibration measurements, then comparative analysis and identification of main sources of sound were executed. The main aim for this project was to analyse noise propagation and identify main noise excitation components resulting in underwater noise propagation. Some preliminary proposals of underwater noise reduction are put forward in the paper.

INTRODUCTION

Among many investigation studies on ship underwater noise emission in 1985 ICES (International Council for the Exploration of the Sea) document “UNDERWATER NOISE OF RESEARCH VESSELS – Review and Recommendations” has been established. This guidance is directed mainly towards fisheries research vessels. It describes fish hearing, vessel noise emission character, underwater noise emission measurement procedures, etc. This guidance is a solid base and guidance for noise emission estimation of other vessels than research ones.

In this paper underwater noise emission of 70m supply vessel (which is to be converted into the seismic vessel) has been evaluated. The main purpose of this analysis was to analyse noise emission of the vessel, identify the main noise sources and give noise damping treatments proposals.

Normal work condition for seismic vessel is that during 5 knot speed, hydrophones are being towed behind the vessel. Air gun produces a sound wave signal, which is propagated through the water into the sea bottom and returns to the hydrophones with different seismic response. In order to record this seismic data with good quality, background noise, emitted by vessel, must be minimized, therefore it is very important for seismic vessel to achieve the minimum underwater noise propagation .

Investigated vessel was equipped with propulsion consisting of:

- two MAN/B&W 8L-28/32A 5440 BHP diesel engines running at 775 rpm
- two 4 blades CP propellers running at 200 rpm
- two transmission gears – gear ratio: 3,875

1. UNDERWATER NOISE MEASUREMENTS

The underwater noise measurements were executed in sea water in Gdansk Bay by the use of hydrophone placed at the distance not more than 100 m, (precisely, for distance between 50 and 100 m) from tested ship (*Fig. 1.1*) and in a depth of 15 m (*Fig.1.2*). Measurement equipment were placed on a support vessel with only switched-on auxiliary generator for equipment powering. Investigated vessel was navigating at steady course with 5 knots (seismic work) and 11,5 knots (nominal) speed.

Fig.1 Investigated vessel

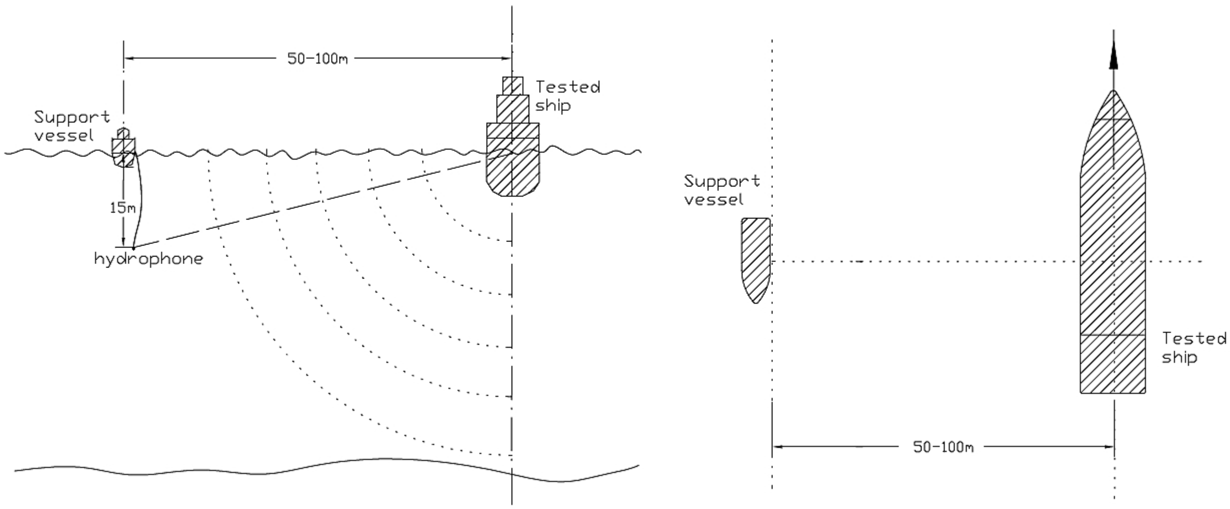

Fig.2 Underwater noise measurement procedure

Below two diagrams of spectral analysis of underwater noise (for 5 knots vessel speed) were presented. On *Fig.1.3* FFT noise spectrum in 5Hz-20kHz frequency range was presented. As one can see that most energy concentrates in low frequency range - upto 1 kHz.

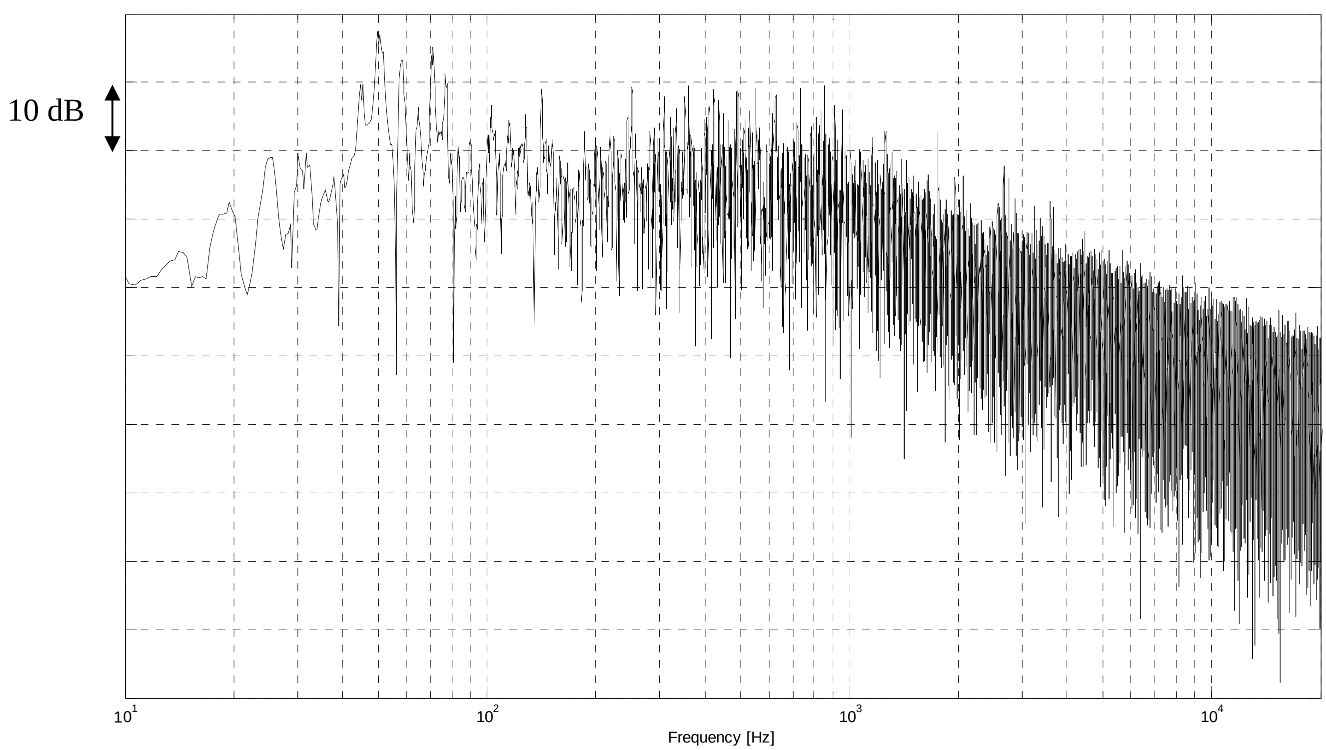

Fig.3 Underwater noise spectrum at 1 m from tested ship [dB re 1uPa]

Therefore on *Fig.1.4* the same measurement data were presented in narrow and linear frequency range [1-1000 Hz].

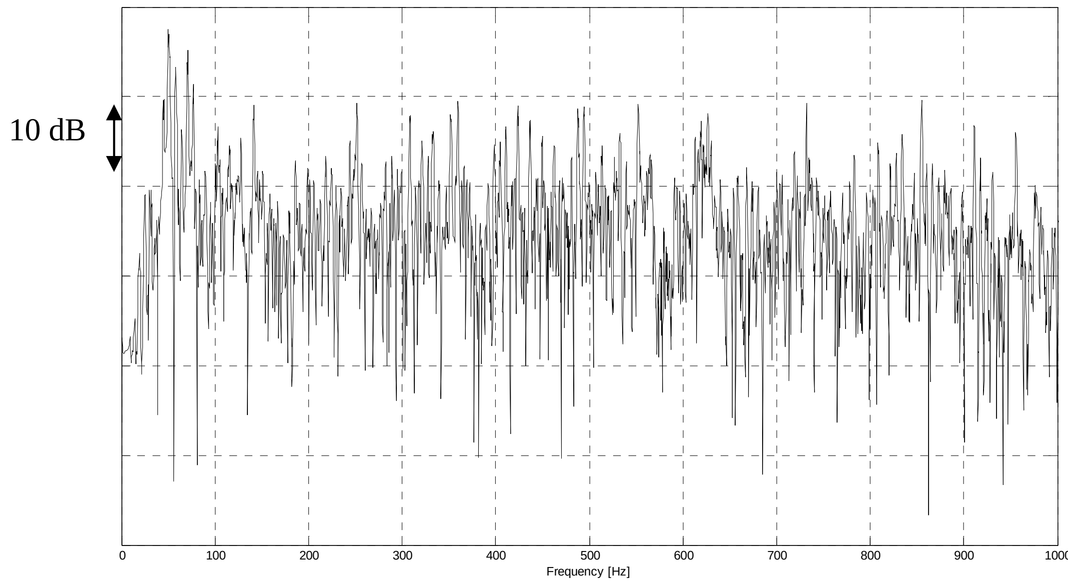

Fig.4 Underwater noise spectrum at 1 m from tested ship [dB re 1uPa] narrow frequency range [1-1000 Hz]

As one can see on *Fig.1.4* that beside low frequency range (upto 100 Hz) there are some significant noise sources at 250 Hz and 630 Hz. Detailed analysis is presented in chapter 4.

2. ONBOARD NOISE MEASUREMENTS

Simultaneously with underwater noise measurements, onboard noise measurements were executed. The main impact was put to estimate noise coming from main noise sources such as main engines, generators, propellers etc. Because of lack of pressure pulses sensors installed above propellers, only resulting vibration and noise level in spaces above propellers were measured.

On-board noise measurements spectrum are presented below (*Fig.2.2*, *2.3*, *2.4* and *2.5*). Measurements were executed at 1m distance from a main noise sources for two vessel speed variants – 5 knots and 11,5 knots. On *Fig.2.1* noise measurement points were marked.

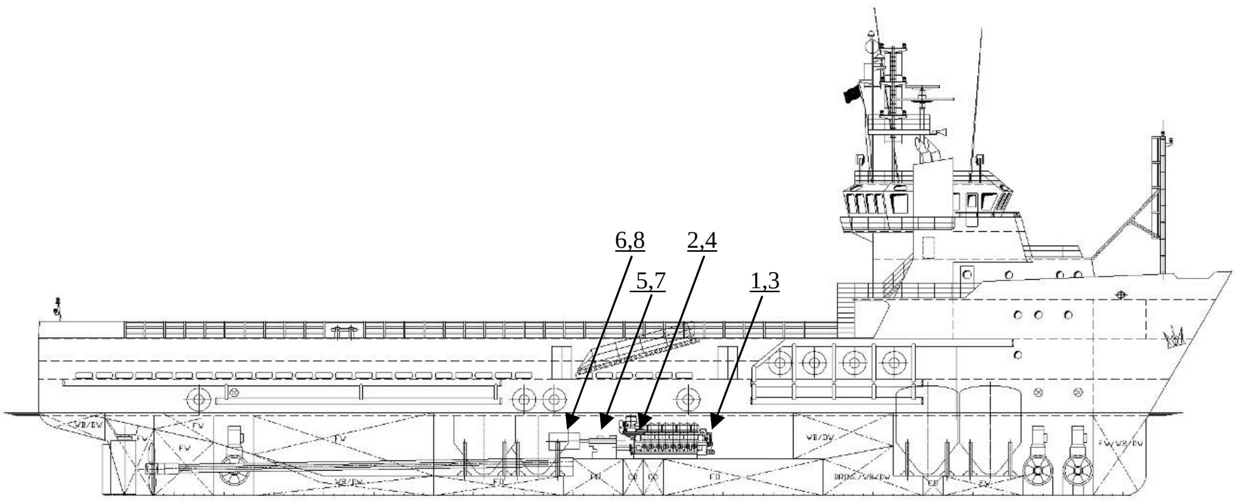

Fig.5 Side view of investigated vessel with on-board noise measurement points marked

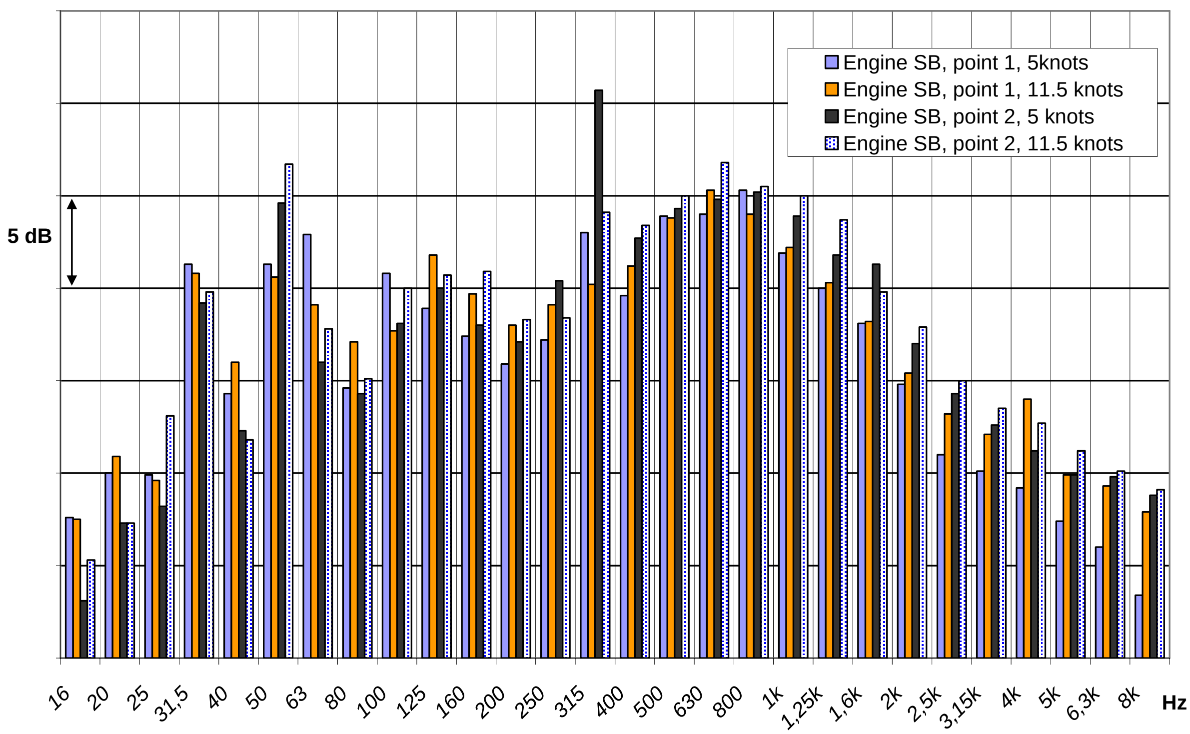

Fig.6 Noise levels at distance 1 m from diesel engine SB (starboard) for 1/3 octave bands

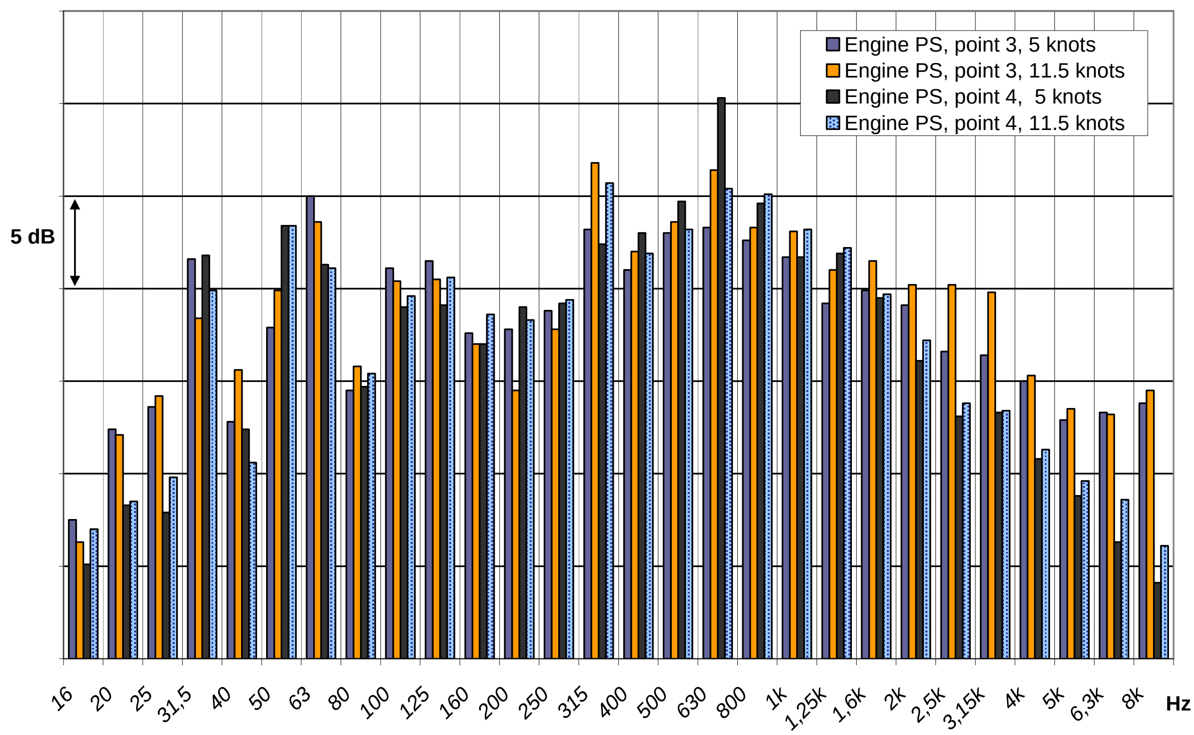

Fig.7 Noise levels at distance 1 m from diesel engine PS (port side) for 1/3 octave bands

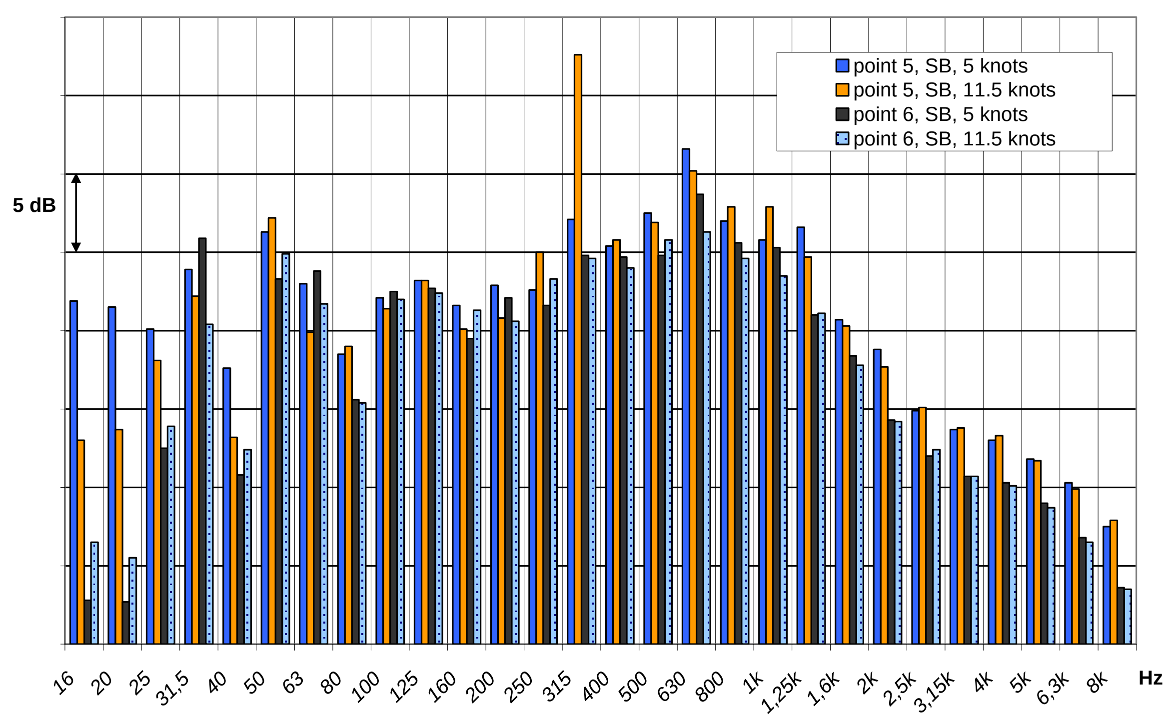

Fig.8 Noise levels at distance 1 m from main gear and shaft generator area (SB) for 1/3 octave bands8.

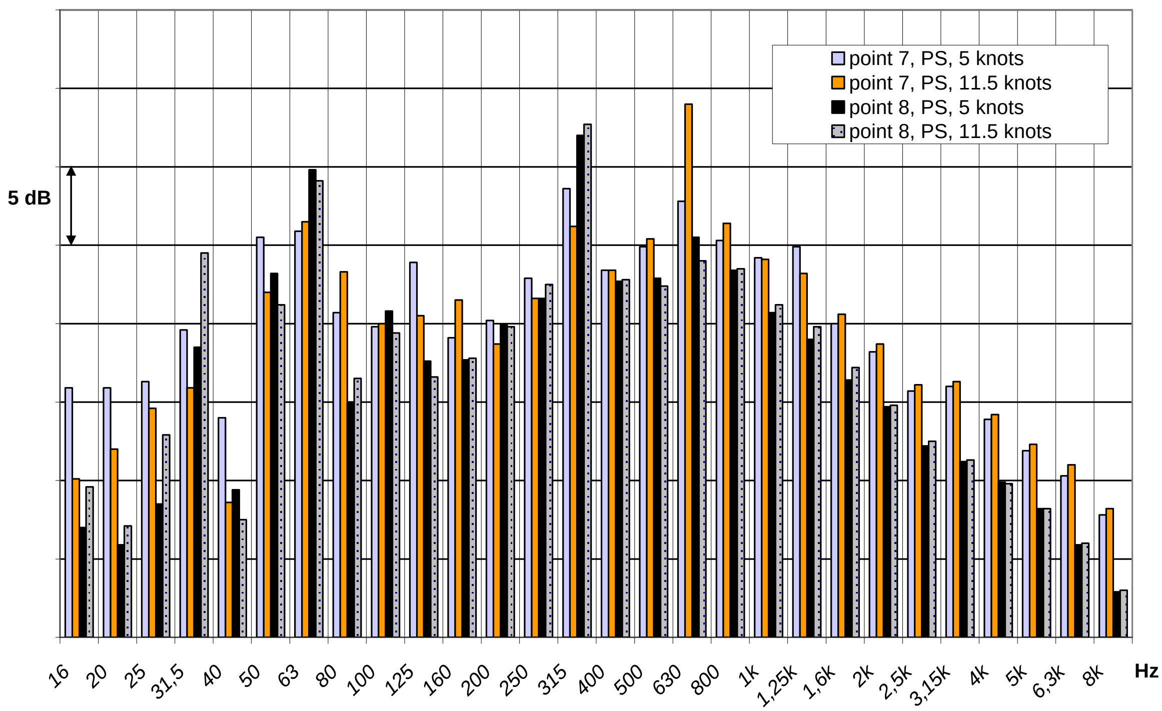

Fig.9 Noise levels at distance 1 m from main gear and shaft generator area (PS) for 1/3 octave bands9

3. VIBRATION MEASUREMENTS

Together with onboard noise measurements, vibration measurements were executed as well. In order to visualise higher frequencies acceleration level were analysed. On *Fig.3.2* one can see main engine foundation. In order to estimate damping of main engine foundation one has measured vibration levels on main engine structure and its foundation (*Fig.3.1*). In many cases this is one of the main structure-borne vibration energy transfer path resulting in underwater noise propagation.

Pt. No.	Vibration velocity level difference between 11,5 kn and 5 kn speed [mm/s]
1H(orizontal)	0.2
2H(orizontal)	0.4
1V(ertical)	0.3
2V(ertical)	0

Fig.10 Main Engine vibration velocity differences between main engine structure and its foundation

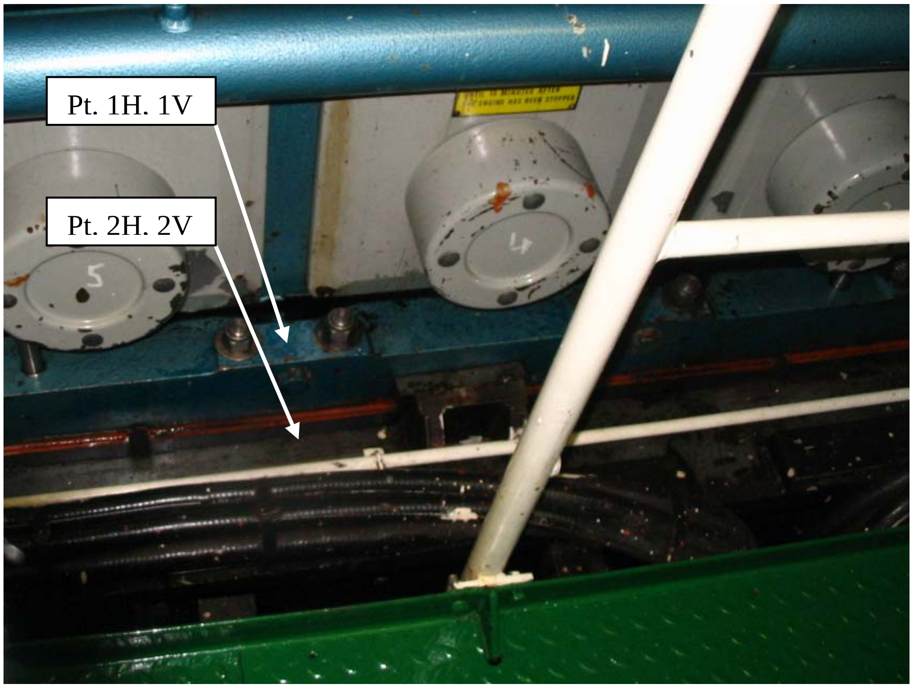

Fig.11 Main Engine with its foundation structure and vibration level measurements points marked

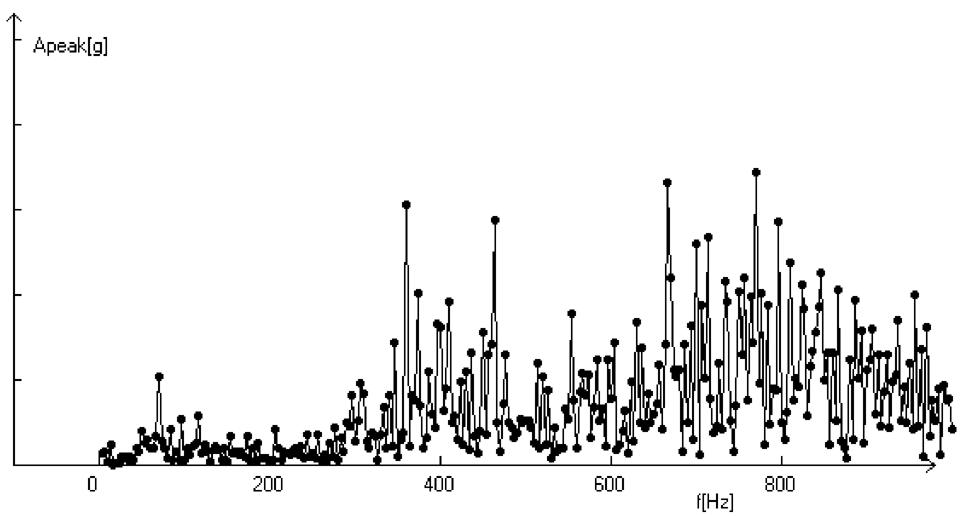

Fig.12 Vertical vibration acceleration level measured for main engine

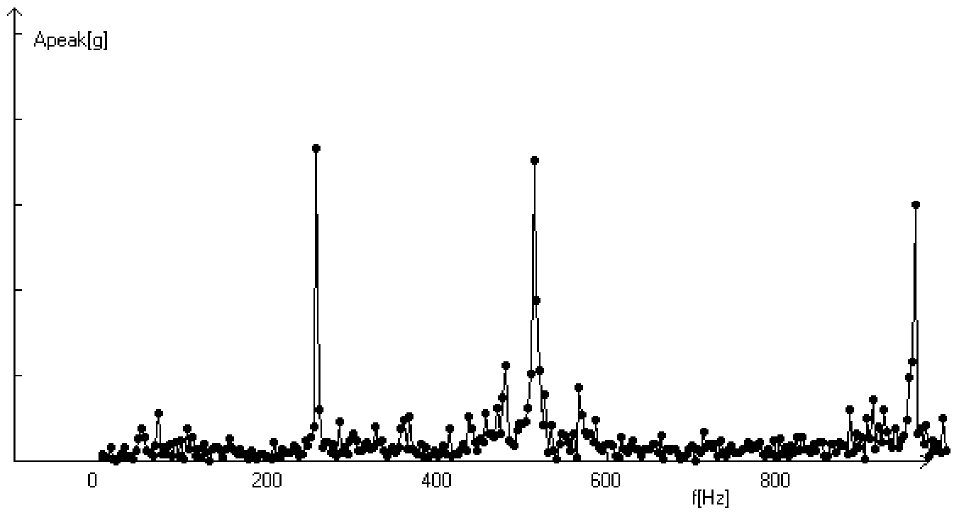

Fig.13 Vertical vibration acceleration level measured for main gear

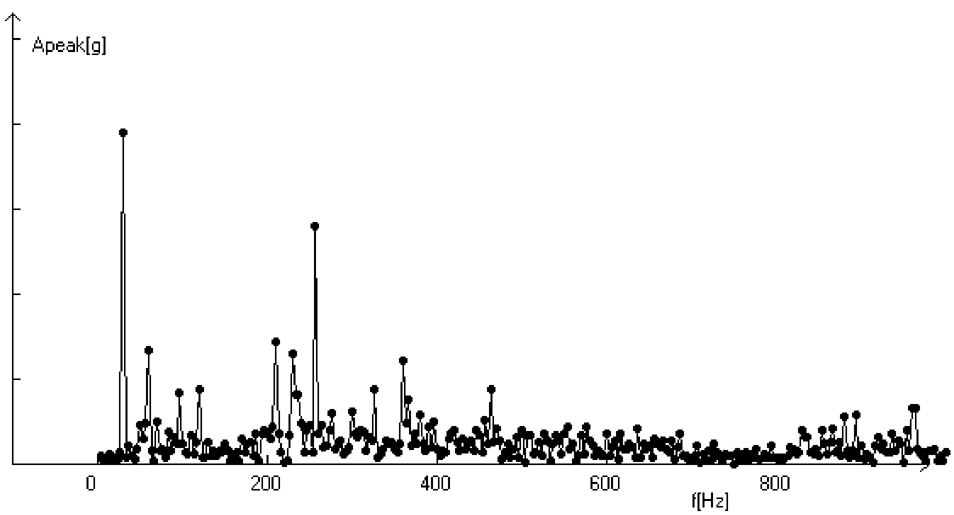

Fig.14 Vertical vibration acceleration level measured for shaft generator

4. MEASUREMENTS ANALYSIS

In *Fig.4.1* dominate frequency of particular noise source were placed for vessel speed 5 knots. The most energy is transmitted directly from diesel engines and main gear. During 5 knots speed, propeller excitation acting on vessel and into the water is not significant. For air-borne noise 1/3 Octave band, for vibration and underwater noise FFT frequencies in Hz are presented.

Diesel Engine	775 rpm	Air-borne noise [1/3 Octave Band]		31,5	50	63		315		630	
		Vibration [FFT]						360		666	770
Aft frame (above propeller)	Type: CP Blades: 4 Speed : 200 rpm Nom Freq = 13,3 Hz	Air-borne noise [1/3 Octave Band]									
		Vibration [FFT]	13				256		566	613	
Main Gear	Ratio: 3.875	Air-borne noise [1/3 Octave Band]		31,5	50			315		630	
		Vibration [FFT]					256		513		
Shaft Generator		Air-borne noise [1/3 Octave Band]									
		Vibration [FFT]		30		60	210, 230, 256				
Underwater noise [FFT]					50	60, 70	256			610, 620	

Fig.15 Characteristics of main noise sources

Very interesting results were obtain during onboard noise measurements. On (*Fig.2.2*, *2.3*, *2.4* and *2.5*) one can notice, that in some frequency bands, during 5 knots speed operation, ship's machinery produces more noise than for 11,5 knots speed. This phenomena is caused by work conditions of the mechanical units, their deformations and little backlashes in gear. Relatively general vibration response of the hull, during 5 knots speed, is calm. On *Fig.3.1* one can see that differences between vibration level measured directly on main engine structure and its foundation is very small. This is due to the fact that engine foundation is very stiff and vibration energy damping coefficient is very small. For Main gear and shaft generator the situation is the same. Therefore vibration excitation energy caused by these machinery units is transferred without any damping to the vessel structure and then through the hull and it's radiated into the water.

In order to minimize underwater noise emission it is essential to change propulsion foundation. The most important change is to install resilient mounts for Main Engine and Shaft Generator in their high energy frequency range .

REFERENCES

1. ICES Cooperative Research Report No. 209, "Underwater Noise of Research Vessels, Review and Recommendations," ISSN 1017-6195, May 1995.
2. Test Report RK-2008/B-029.
3. Test Report RK-2008/B-030.