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UNDERWATER MEASUREMENTS OF NARROW BEAM SONAR ARRAY

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The measurements of acoustic parameters are indispensable in quality control of underwater acoustics systems like sonar. The "Source Level - SL" is a good parameter for sonar's quality evaluations among majority of active sonars. However, this measurement is difficult to use in field conditions, particularly for sonars having narrow beam transducers. The measurement of such a systems require stable conditions, which are hard to achieve in the sea. The paper presents the new method of source level measurement for the narrow beam sonars in the field conditions. The measurement set consists of the reflecting corner and the hydrophon. The set is anchored at selected depth, which may be controlled. The narrow beam transducer is placed on the rotary device, which is mounted on the stable pier or other hydrotechnical constructions. The results of SL measurements are presented for side looking sonar's transducers with 1 deg and 4 deg beams. The analysis of the measurement accuracy was also carried out.

INTRODUCTION

Periodical quality control of the sonar devices is needed during it's exploitation. It's well known that the quality of device is determined by extent to comfortable of the sonar's technical characteristics and it's technical requirements. The assertion of sonar's quality needs not only technical control in electronic laboratory but the control of acoustical parameters of sonars in water is needed as well.
The "Source Level – SL" is a good parameter for sonar's evaluations for majority of active sonars. As per an inspection this parameter usually parallel determines the quality of sonars.

1. SL MEASUREMENTS

A comparatively large distance between from the sonar's transducers is needed in measurements relating sonars with narrow beam transducers as side-looking sonars. The control hydrophone must be placed beyond the Fresnel zone of the sonar transducer. These conditions are good enough by distance no less then $2L^2/\lambda$ (L – length of transducer , λ - waves length) - it is far field zone. In reality this distance should be more than 40 m. In this case the SL measurement is usually realised in field conditions, for example in harbour's

docks. It's all plain sailing, when the weather is good. But when the wind is fresh and there are free waves, to secure a stable measurements conditions is very difficult.
As known, Source Level is determined as a pressure of acoustic waves at 1 m from transducer's face on it's main acoustical axis. But in reality, because of Fresnel zone, the pressure can be measure at the same distance for transducer face's, in far field zone.
So, when SL is in dB re 1 Pa ref 1 m :

$$SL = 20 \log d + 20 \log p \quad (1)$$

Determined pressure by hydrophone with sensitivity s:

$$\mathbf{SL = D + V - S} \quad (2)$$

where:

D = distance transducer – hydrophone [dB re 1 m]
V = output hydrophone [dB re 1 V]
S = hydrophone sensitivity [dB re 1 V/ 1 Pa].

Source Level is specified by measurement of the distance from transducer's face to hydrophone and voltage level generated on hydrophone output from signals transmitted by sonar.

2. THE METHOD OF SL MEASUREMETS

In order to get the required stable measurement conditions there is made a measurement set shown in fig.1. The narrow beam sonar's transducer is placed on rotary device. This device is mounted hard on the stable harbour's pier or other hydrotechnical construction. The transducer's face is arranged to be horizontally placed as well as it's axis look for a hydrophone.

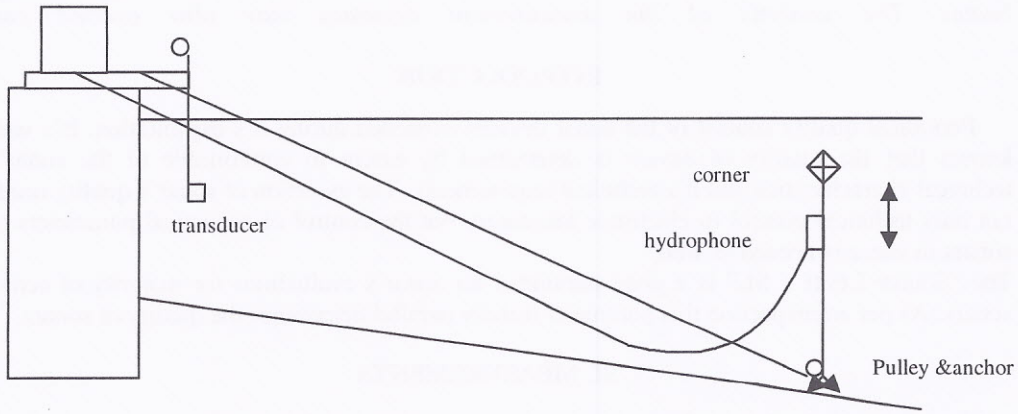

Fig.1.SL measurement.

In the far field zone, the hydrophone is localised. This set has an reflected corner. About 1 m below corner the hydrophone is placed in the water. It's cable goes to place, where the measurement; it is placed on the pier, near rotary device. The corner's depth in water area,

and so hydrophone's is controlled by using a rope. This rope via the pulley, goes to the same place where is the measurement set. The pulley is joined with an anchor. The anchor is placed on the bottom of the sea. In this case dislocation of hydrophone's depth is being done by changes of rope strain. The hydrophone is situated in vertically to transducer's axis.
The corner allows without any effort to measure the transducer – hydrophone distance by sonar. Source Level was calculated from formula (2).
The measurement set based on PIC microcontroller is used. This set calculated the "transducer – hydrophone" distance, putting the "time window" for direct signals, conventing A/C direct signals and transmiting the date via RS to host. This set may additionally supply and release the sonar's towed fish. Then a sonar's board set isn't necessary for measurement.
A Delphi's program is used as host (PC or notebook). It store and prints the measurement results.
For using presented method of SL measurements are not required the stable conditions. By this method are reduced all hardship connected with measurement on the open waters, especially having big waves in measurement water area.

3. RESULTS OF MEASUREMENT.

Presented method was used for technical control of side-looking sonars. There are some examples of results shown in table 1. Fig. 2 shows an object of control.

Table 1.

Results of measurements					
board	power	beam	SL*1	SL*2	SL*3
port	125 W	1 deg	101,2	99,6	97,5
port	500 W	4 deg	100,8	99,4	97,7
starboard	125 W	1 deg	98,3	96,4	97,1
starboard	500 W	4 deg	98,1	96,3	97,2

Standard SL>=95 dB re 1 Pa ref 1m

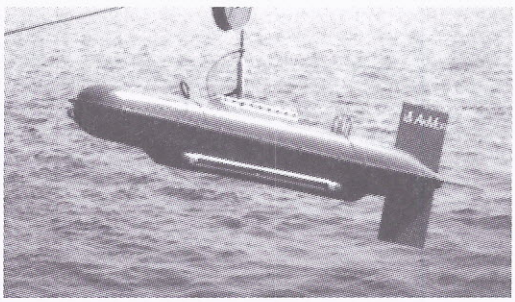

Fig.2. The object of measurement

4. THE ACCURACY OF MEASUREMENTS.

As show in [2], the error of measurement SL in good weather conditions is less then 5%. Good conditions – it means that level of reflected acoustic signals is low. When this level is relatively high, the method of reducing this signals must be employed [1, 3].

In the formula 2 there is disregard the absorption of the acoustic waves on the way "transducer – hydrophone". It isn't essential when technical requirements say that SL must be "no less then" and SL is "more then".
When we needs this factor, we must make measurement for two distances every one to be done in far field zone.
If first distance is d_A and second is d_B, then SL may be calculated from formula:

$$SL = (1 + k)\,\mathbf{D}_A - k\mathbf{D}_B + (1 - k)\mathbf{V}_A - k\mathbf{V}_B - \mathbf{S} \qquad (3)$$

where:

$k = d_A/(d_B - d_A)$
d_A, d_B – distance [m]
$\mathbf{D}_A$, $\mathbf{D}_B$ – distance [dB re 1 m]
$\mathbf{V}_A$, $\mathbf{V}_B$ - hydrophon output [dB re 1 V]

For 150 kHz transducers the results specified using formula (3) are ca 2 dB higher then results specified by formula (2).

5. CONCLUSION

Presented method makes possible a good performance of measurements relating sonars parameters. The measurements may be done in typical weather conditions. Since SL measurements may be applied for sensitivity or directivity of transducers. In practice it's good for technical inspections of side – looking sonars while running.

REFERENCES

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