ECHO SOUNDING CORRECTIONS

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In the Soviet Union frequent use is made of echo sounders in routine hydrographic surveying, and all important surveys are carried out with the help of echo sounding apparatus. Depths recorded on echograms as well as depths entered in the sounding log must be corrected for a value which is the result of the algebraic addition of two partial corrections as follows :

ΔZ_f : correction for « level error »

ΔZ_λ : correction of echo

When the value of the total correction is less than half the sounding accuracy, it is disregarded.

The maximum tolerance figures allowed in sounding are shown below :

From	0	to 20 m.	: 0.4 m
	21	to 50 m.	: 0.7 m
	51	to 100 m.	: 1.5 m
	101	and over	: 2% of sounding depth

Correction for level error. — The correction for the « error in level » is computed according to the following formula :

$$\Delta Z_f = n - f \qquad (1)$$

n : reading of nearest tide gauge, corresponding to datum level determined;

f : reading of tide gauge at time of taking soundings.

Echo correction. — The depths determined by echo sounding must be subjected to corrections which are obtained as follows :

(a) Immediately determined by calibration, or

(b) According to the hydrological data available.

I. — Determination of corrections by calibration

When determining echo corrections by calibration, the soundings are corrected as follows :

(1) Determination of total correction ΔZ_T in sounding area by calibration of echo sounding machine ;

(2) ΔZ_n correction for difference in speed of rotation of indicator disk with respect to speed determined during calibration ;

The ΔZ_n correction is applied when the number of revolutions of the indicator disk differs by more than 1 % during sounding operations from the value obtained during the initial calibration.

The value of ΔZ_n may be obtained by the following formula :

$$\Delta Z_n = \left(\frac{n_T}{n_H} - 1 \right) Z \qquad (2)$$

ΔZ_n : correction required for depth measured

n_T : number of revolutions obtained during calibration

n_H : number of revolutions observed

Z : depth measured

(3) ΔZ_L correction of « separation error », i. e. the correction due to the difference between the actual « separation » value and the computed value used (this correction is dependent on the graduation of the echo sounder scale).

The ΔZ_L correction of the separation error is obtained as follows :

— For echo sounders equipped with a uniform scale according to the formula :

$$\Delta Z_L = \frac{L^2}{8Z} \qquad (3)$$

This correction is invariably preceded by the minus sign.

— For echo sounders equipped with a non-uniform scale according to the formula :

$$\Delta Z_L = Z - \sqrt{Z^2 - \frac{L_o}{2}(L - L_o)} \qquad (4)$$

L : distance between oscillators

L_o : distance between oscillators obtained at time of computing echo sounder scale

Z : depth obtained

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Calibration of the echo sounder for determining the total ΔZ_T correction is accomplished by :

— The control table ;
— The control oscillator ;
— Comparison with sounding data.

Echo sounder calibration by control table

Echo sounder calibration with the control table may be carried out at 30- to 40-metre depths in areas only slightly affected by currents. This method of calibration is very convenient for boat-sounding purposes.

The total ΔZ_T correction obtained by calibrating with the control table is determined as the difference :

$$\Delta Z_T = Z - Z_\varepsilon \qquad (5)$$

Z_λ : value of sounding obtained by sounding line

Z_ε : value of sounding obtained by echo sounder

By calibrating the echo sounder with the control table, the ΔZ_L correction for separation error is included in the total correction, and must therefore be disregarded.

Calibration of the echo sounder takes place daily in typical sounding areas, at the beginning and end of working hours, and if necessary more frequently. The difference in the value of the total corrections as determined by two successive calibrations and adjusted for the change in the speed of rotation of the indicator disk must not exceed twice the value of the sounding accuracy in the corresponding range.

The depth figures obtained must be corrected by taking the arithmetical mean of the correction values determined by the two successive calibrations between which the sounding occurs.

Echo sounder calibration by control oscillator

Calibration of the echo sounder by means of the control oscillator is carried out by sinking the accessory receiver-oscillator at various depths down to 150 m.

The total ΔZ_T correction obtained by calibrating with the control oscillator is determined as the difference :

$$\Delta Z_T = Z_\lambda - 2Z_\varepsilon \qquad (6)$$

Z_λ : value of sounding obtained by sounding line

Z_ε : value of sounding obtained by echo sounder

If the echo sounder is calibrated without a recorder, twice the value of the depth-reading must be corrected by the algebraic addition of the initial value appearing on the depth-indicating device at the time of transmitting the ultrasonic signal.

If the reading upon transmission is located to the left of zero, the correction will be plus, and if to the right, minus.

An example of total correction computation for an echo sounder unequipped with a recording device is given below :

Reading of line sounding Z_λ	Echo sounder reading		Reading × 2	Initial signal reading	Corrected reading × 2	Total correction
	No. 1	No. 2				
10	4.8	4.8	9.6	99.2	10.4	— 0.4

If the echo sounder is calibrated on board ship and if the horizontal distance l as shown in the figure between the control oscillator and the transmitting oscillator is more than one metre (Fig. 1), the total correction obtained for shallow depths by formula (6) must be adjusted by $\frac{l^2}{2Z_K}$ which is always positive ; Z_K is the difference between the depth of the control oscillator and the transmitting oscillator.

II. — Determination of echo sounding corrections by means of hydrological data

In determining echo sounder corrections on the basis of data obtained by hydrological observation, ΔZ_r is computed according to the following formula :

$$\Delta Z_r = \Delta Z_v + \Delta Z_n + \Delta Z_h + \Delta Z_L + \Delta Z_o \qquad (7)$$

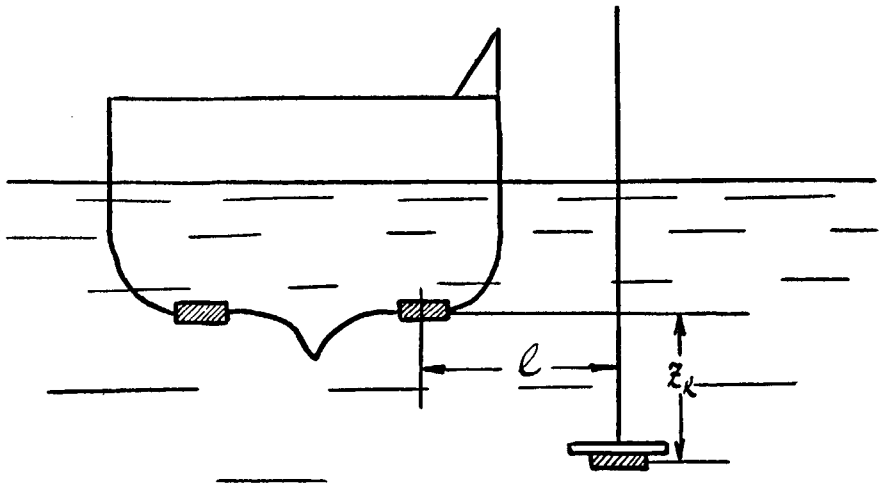

Fig. 1.

ΔZ_v : correction for difference between vertical speed of sound in water and nominal speed of echo

ΔZ_n : correction for speed of rotation of indicator disk with respect to nominal speed

ΔZ_b : correction for depth of oscillators with respect to surface

ΔZ_L : correction for separation error (distance between oscillators)

ΔZ_o : correction for transmission signal reading.

The correction for the variation of the vertical speed of sound in water in a given sounding area is obtained on the basis of hydrological observations at special stations.

The values of the ΔZ_v corrections used in plotting correction graphs are obtained from the following formula :

$$\Delta Z_v = Z_i \left(\frac{V_i}{V_o} - 1 \right) \qquad (8)$$

Z_i : depth in metres for which the correction is made

V_i : value of speed of sound in water in metres per second, corresponding to the depth

V_b : value of speed of sound in water adopted for this type of echo sounder

The ΔZ_f correction for the depth of the oscillators is computed by means of the following formula :

$$\Delta Z_b = H\varphi + (H_A - H\varphi)\, q - h \qquad (9)$$

H_φ : draught in bow of ship

H_A : draught astern

h : vertical distance between oscillators and lower part of keel

$$q = \frac{a}{a+b} \qquad (10)$$

a : horizontal distance from bow to oscillators

b : horizontal distance from stern to oscillators

The ΔZ_n correction for the difference in speed of rotation of the indicator disk with respect to the normal speed is computed according to formula (2), in which the normal number of rotations for the echo sounder considered is substituted for n_T. The correction for separation error ΔZ_L is computed according to formulae (3) and (4).

The ΔZ_o correction is determined according to the position of the initial transmitted signal with reference to zero.

In addition to the above-mentioned method of determining the correction, the latter may be computed as the difference :

$$\Delta Z_b = H - h \qquad (11)$$

H : draught at time of sounding

h : vertical distance of oscillators to edge of keel measured at time of installation of oscillators

If the value of h has not been measured, it must be computed during echo sounder control operations before the survey by comparing the depths measured by the echo sounder and by wire sounding. In this case the ΔZ_b correction is equivalent to :

$$\Delta Z_b = Z_r - (Z_\varepsilon + \Delta Z_v + \Delta Z_n + \Delta Z_L + \Delta Z_o) \qquad (12)$$

Z_λ : actual depth obtained by wire sounding

Z_ε : echo sounder reading ; other designations remain unchanged

Then h is determined from the following formula :

$$h = H - \Delta Z_h \qquad (13)$$

In order to obtain the value of h, the mean value of the draught of the ship is determined daily, before and after sounding operations.

A check should be made of the echo correction values that have been determined by regularly comparing the echo soundings obtained after correction with the depths measured by sounding line.

Such check comparisons must be made every day during echo sounder control, prior to the survey, during sounding, before and after each day's work, and in case of doubt as regards normal echo sounding procedure.