EM Technical Note

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Subject: Sound Levels from Kongsberg Multibeams

The power output level of an echo sounder is normally specified by giving its source level in dB relative to 1 μPa at a distance of 1 m from the transmit transducer. However this is really a measure of the pressure level of the output sound wave and is only directly applicable in the farfield. The intensity (power per unit area) of a sound wave can be found from the pressure level by the relation $I = p^2/\rho c$ where ρ is the water density and c the speed of sound. The quantity ρc is the acoustic impedance of water and for sea water is nominally taken to be 1.5×10^6 kg/m^2s. Thus a pressure level in sea water of 1 μPa is nominally equal to an energy intensity of 0.667×10^{-18} W/m^2, and a pressure level of for example 210 dB corresponds to an intensity of 667 W/m^2.

In the farfield the pressure level of a sound wave will fall off with the square of the distance, this because of spherical spreading of the wave, and the wave will be further attenuated due to absorption loss. In the nearfield the pressure level will be nominally constant as there is no spreading. If the transmit transducer generating the sound wave is rectangular, there will be a transition region in which the pressure will fall of proportionally to the distance due to cylindrical spreading in the direction parallel to the shortest side of the transducer. It may be noted that in the nearfield the pressure level will have large variations, with peaks up to about twice the nominal level and also deep nulls, this effect will however be ignored in this note.

The source level is given by $SL = 170.8 + 10 \lg P_{Ac} + DI$. P_{Ac} is the acoustic power which is typically half the electric power applied to the transmit transducer. DI is the transducer's directivity index which for a rectangular flat transducer can be approximated by $DI = 46.2 - 10 \lg \theta_x \theta_y$ where θ_x and θ_y are the transmit beamwidths in degrees along and across respectively. The relation between beamwidth and transducer array length, L, depends upon the applied shading and the number of elements in the array, typically it would be $\theta = 65\lambda/L$ where λ is the wavelength. The nearfield limit is conventionally given by $R = L^2/\lambda$.

To derive the pressure levels in the nearfield from the source level of an echo sounder one must first calculate the pressure level at the largest farfield limit assuming spherical spreading from the 1 meter reference level used in defining the source level. From the largest to the smallest nearfield limit the pressure level will increase linearly with distance, and from the smallest nearfield limit in to the transducer level the pressure level will be constant.

If the source level of the echo sounder is not known, but both beamwidths or transducer array lengths or even just area are, the maximum possible pressure level may still to a good degree be estimated. Then one has to rely upon the fact that there is a maximum acoustic power intensity that can be applied to a transducer in the order of 2-5 W/cm^2 to avoid cavitation (lowest number is typical at say 12 kHz, highest at say 100 kHz). With shading being applied in one direction the power will be reduced to about 50-60%, and for both directions to about 30%.

The calculations outlined above are for the on-axis direction (usually straight down). Off-axis the pressure level will fall rapidly for a narrow beam (alongtrack for a multibeam echo sounder), the level will be 20 dB down at a little more than twice the beamwidth. Acrosstrack, the pressure level will typically be 20 dB down for angles of more than 75-80° of the vertical for flat arrays. At for example 45° the closest nearfield distance will be half that of on-axis, leading to a 3 dB reduction in pressure level for distances larger than the nearfield distance on-axis. At 60° the nearfield distance will be reduced by another factor of two, and taking into account the usual level reduction at large beam angles also, the pressure level would typically be down about 8 dB compared to on-axis. At 70° the level will be about 16 dB down due a further halving of the nearfield distance and the beam pattern drop-off. For multibeams which use sectorized transmission such as most current Kongsberg systems, beam defocusing is applied in the central sector(s) in shallow waters which implies that the nearfield will be shortened and the drop-off in pressure level starts earlier. For curved transducers the nearfield limit and the pressure level will stay fairly constant across the whole angular coverage angle.

Sonars may be transmitting horizontally and with a sound speed profile where the sound speed lessens toward the surface the spreading will cylindrical even in the farfield due to ducting causing a sound channel at the surface. For multibeam echo sounders this is usually not the case, except for tilted systems such as with the dual head EM 3002.

The following table shows the relevant parameters for the currently available Kongsberg multibeam echo sounders. For each model the alongtrack (transmit) beamwidth, the source level in dB re 1μPa at 1 meter, calculated nearfield distances and pressure levels in dB re 1 μPa at the nearfield distances are provided. The effect of absorption loss is not included in this table.

System	SL	NF1	PL@NF1	NF2	PL@NF2
SBP 120 3°	230	0.8m	209	140m	187
SBP 120 6°	224	0.8m	209	35m	193
SBP 120 12°	218	0.8m	209	9m	199
EM 122 0.5°	245	2.8m	208	1840m	180
EM 120/122 1°	242	2.8m	211	460m	189
EM 120/122 2°	236	2.8m	211	115m	195
EM 302 0.5°	241	1m	212	720m	186
EM 300/302 1°	237	1m	214	180m	192
EM 300/302 2°	231	1m	214	45m	198
EM 710 0.5°	232	0.3m	213	220m	185
EM 710 1°	228	0.3m	215	55m	193
EM 710 2°	222	0.3m	215	14m	199
EM 1002 (3°)	225	3.2m	210	10m	205
EM 2000 (1.5°)	218	0.8m	208	12m	196
EM 3002 (1.5°)	216	0.01m	227	7m	199

In the next table the pressure levels at a set of fixed distances are given and also the range at which the pressure level is 180 dB re 1 μPa. Note that the figures are worst case, i.e. on-axis and with no defocusing. Note also that in this table absorption loss has been taken into account, but not in the former, using absorption coefficients of 0.2 dB/km at 4 kHz, 1 dB/km at 12 kHz, 6 dB/km at 30 kHz, 30 dB/km at 100 kHz, 50 dB/km at 200 kHz and 70 dB/km at 300 kHz.

System	PL@1m	PL@10m	PL@100m	PL@1000m	R@180dB
SBP 120 3°	208	198	188	170	310m
SBP 120 6°	208	198	184	164	160m
SBP 120 12°	208	198	178	158	80m
EM 122 0.5°	208	202	192	181	1100m
EM 120/122 1°	211	205	195	180	1000m
EM 120/122 2°	211	205	195	174	550m
EM 302 0.5°	212	202	193	171	600m
EM 300/302 1°	214	204	193	165	400m
EM 300/302 2°	214	204	190	159	250m
EM 710 0.5°	208	197	182	112	120m
EM 710 1°	210	199	182	108	110m
EM 710 2°	210	199	176	102	75m
EM 1002 (3°)	210	204	179	105	90m
EM 2000 (1.5°)	207	196	168	NA	45m
EM 3002 (1.5°)	207	194	162	NA	35m