Date: **September 20, 2005**
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Revised: **Jun 6, 2018**
Systems EM 1002 and EM 2000 are removed
Systems EM 2040 and EM 2040C are added
The table at the end of this document is corrected (effect of absorption was too high in the old table)
Revised Aug 8th, 2019 (Ståle M)
Added Source level for Single Beams in a separate table
Revised March 9th, 2021 (Ståle M)
Added calculation for reduced power (PL) affecting Source level (SL) for Multi/Single Beams in the end of the document.
Revised Oct. 24th, 2022 (Ståle M)
Added MKI and MKII for EM304

Subject: Sound Levels from Kongsberg Multibeam' s and Single beams

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 $1.5x10^6$ kg/m^{2}s. Thus, a pressure level in sea water of 1 μPa is nominally equal to an energy intensity of $0.667x10^{-18}$ 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 $SL = 170.8 + 10lgP_{Ac} + DI$. 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 $DI = 46.2 – 10lg\theta_x\theta_y$ 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 must 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. Across track, 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.

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.

Multibeam Systems

System	SL	NF1	PL@NF1	NF2	PL@NF2
SBP 120/300/27/29 3°	230	0.8 m	209	138 m	187
SBP 120/300/27/29 6°	224	0.8 m	209	34 m	193
SBP 120/300/27/29 12°	218	0.8 m	210	8 m	200
EM 122/124 0.5°	245	3.5 m	207	1749 m	180
EM 120/122/124 1°	242	3.5 m	210	438 m	189
EM 120/122/124 2°	236	3.5 m	210	110 m	195
EM 302 /304 MKI and MKII 0.5°	241	1.3 m	211	704 m	184
EM 300/302/304 MKI and MKII 1°	237	1.3 m	213	175 m	192
EM 300/302/304 MKI and MKII 2°	231	1.3 m	213	43 m	198
EM 710/712 0.5°	232	0.3 m	213	246 m	184
EM 710/712 1°	228	0.3 m	215	61 m	192
EM 710/712 2°	222	0.3 m	215	15 m	198
EM 3002 (1.5°)	216	0.01 m	227	8 m	198
EM 2040 (0.5°)	217	0.002 m	225	82 m	179
EM 2040 (1.0°)	211	0.002 m	225	20 m	185
EM 2040C (1.3°)	205	0.0005 m	227	11 m	183

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 120/300/27/29 3°	209	199	189	170	314 m
SBP 120/300/27/29 6°	209	199	184	164	158 m
SBP 120/300/27/29 12°	209	198	178	158	79 m
EM 122/124 0.5°	207	203	192	182	1331 m
EM 120/122/124 1°	210	206	195	181	1108 m
EM 120/122/124 2°	210	206	195	175	590 m
EM 302/304 MKI and MKII 0.5°	211	202	192	175	690 m
EM 300/302/304 MKI and MKII 1°	213	205	194	171	501 m
EM 300/302/304 MKI and MKII 2°	213	205	190	165	290 m
EM 710/712 0.5°	208	198	185	142	183 m
EM 710/712 1°	210	200	185	138	150 m
EM 710/712 2°	210	200	179	132	92 m
EM 3002 (1.5°)	207	195	169	86	44 m
EM 2040 (0.5°)	198	187	170	87	35 m
EM 2040 (1.0°)	198	187	164	81	28 m
EM 2040C (1.3°)	194	183	158	75	15 m

Single Beam

The table below shows the Source Level (SL) for all Single beam transducers. Some abbreviations for this list: (For combi transducers the lowest frequency is first)

SL: Source Level in dB (re 1µpa per 1m)
TP: Transmit Power (Max) (in Watts)
BW: Band Width (in degrees), If not circular Longitudinal first.
TR: Transmit Response in dB (re 1µpa per V)
RS: Receive Response in dB (re 1V per µpa)

System	SL	TP	BW	TR	RS
12Khz 12-16/60 18+1 Element	221,8	2000	16	171	-168,5
12Khz 12-16/60 1 Wide Element	197,8	100	60	142	-168,5
15Khz (15-17 Airmar)	228,4	4000	17	165	-175
18Khz (18/11)	225,8	2000	11 ±2	176 ±2	-168 ±2
38Khz (38/7)	230,1	2000	7	182,5 ±2	-170,5 ±2
38Khz (38/9)	225,6	1500	9	177	-171
38/200Khz (Combi W)	222,8 /220,7	400 /250	31	164 /155	-184 / -197
38/200Khz (Combi C and D)	218,8 / 226,3	1000	13/21 and 7	170 /178	-178 / -185
50Khz (50/7)	228,8	2000	7	177,5	-173
50Khz (50/18)	214,8	500	18 ±3	207 ±2	-181 ±2
50/200 Khz (Combi C and D)	221 / 227	1000	10/16 and 7	172 / 178	-179 / -185
120Khz (120-25)	227,8	1000	10 ±2	176,5 ±2	-183 ±2
120Khz (SideScan)	223,3	1000	1,9/55	?	?
200Khz (200 7F)	226,3	1000	7 ±1	180 ±2	-185 ±2
200Khz (200 7G)	226,3	1000	7 ±1	215 ±2 re 1 µpa per A	-185 ±2
200Khz (200 9G)	221,6	500	9	175 ±2	-169 ±2
200Khz (200 28E)	228	1500	7 ±1	180 ±2	-185 ±2
200Khz (200-35E)	235,8	2000	3 ±0.5	186,5	-177
200Khz (Side Scan)	226,8	1000	0,5/49	182 ±2	-167 ±2
500Khz (500-3G)	231,4	500	3	186 ±2	-189 ±2
500Khz (SideScan)	230,8	1000	0,35 / 60	179	-196

Source level (SL) are reduced with 3dB when the Transmit Power (PL) is reduced with 50%
Source Level (SL) are reduced with 6dB when the voltage is reduced with 50%