Digiquartz® Depth Sensor Ocean-Depth Conversion

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This application note provides practical information for determining the linear depth in sea water from hydrostatic pressure measurements. It is recommended to measure hydrostatic pressure in pressure units of [decibar], which is about 1 [meter] of depth, using a Digiquartz® Depth Sensor. A computer program in the data acquisition system is needed to perform the conversion in real-time, or alternatively, a spreadsheet can be used to convert pressure values to linear depth offline. For added clarity, engineering units are shown in [brackets].

The standard ocean depth formula (see Unesco reference below) is:

$z = D/\langle g \rangle$

where z is depth in [meter], D is the geopotential distance fitted to a fourth order polynomial in pressure, and <g> is the average gravity.

$D = C_1 P + C_2 P^2 + C_3 P^3 + C_4 P^4$

$\langle g \rangle = g(\theta) + \frac{1}{2} \gamma P$

Parameter	**Value**	**Units**
P	Measured gauge pressure	[decibar]
C_1	9.72659	[J/kg/decibar]
C_2	-2.2512 E-5	[J/kg/decibar^2]
C_3	2.279 E-10	[J/kg/decibar^3]
C_4	-1.82 E-15	[J/kg/decibar^4]
g(q**)**	Local gravity at latitude θ	[m/s^2] - see formula below
g	2.226 E-6	[m/s^2/decibar]

The standard ocean depth formula is derived using a water density profile at a salinity S = 35, a temperature T = 0 [deg C], and a compressibility correction of second order.

Check values: (Pressure in [decibar], depth in [meter])

Pressure/Latitude	q = **0 [deg]**	q = **30 [deg]**	q = **45 [deg]**	q = **60 [deg]**
500 [decibar]	496.65 [m]	496.00	495.34	494.69
1000	992.12	990.81	989.50	988.19
2000	1979.55	1976.94	1974.33	1971.72
5000	4915.04	4908.56	4902.08	4895.60
10000	9725.47	9712.65	9699.84	9687.03

Gravity varies with latitude. The standard gravity correction used in the standard ocean depth formula is

$g(\theta) = 9.780318\ (1.0 + 5.2788\ E\text{-}3\ \sin^2\theta + 2.36\ E\text{-}5\ \sin^4\theta)\ [m/s^2]$

Check values:

Latitude q	**0 [deg]**	**30 [deg]**	**45 [deg]**	**60 [deg]**	**90 [deg]**
Gravity	9.780318	9.793240	9.806190	9.819169	9.832177

Gravity decreases towards the center of the earth, but the ocean and crustal densities are low enough that it increases initially by γ = 2.226 E-6 [m/s^2] per [meter] (or per [decibar] equivalent pressure) of ocean depth. The ocean formulas are usually corrected for this gravity gradient by using an average gravity $g = g(\theta) + \frac{1}{2}\gamma P$, where P is pressure depth in [decibar]. The gravity gradient correction amounts to 2.8 [m] at a depth of 5000 [m].

If the Digiquartz® Depth Sensor is operated as a conventional pressure sensor, it is recommended to convert the pressure output into pressure units of [decibar]. With an intelligent RS232/485 interface, this can be accomplished by setting the unit selection to UN=0 (user-defined units) and UF=0.6894757 (conversion from [psi] to [decibar]).

Note that the pressure P is gauge pressure, which is the measured absolute pressure minus the atmospheric pressure at the surface. This can be accomplished either by a simultaneous measurement of surface pressure, by subtraction of a fixed value, or by taring the depth sensor at the surface. In all cases, the subtraction must be performed in the same pressure unit, e.g. in [decibar]. Standard surface pressure is 10.13 [decibar] (= 1 [atmo]) with typical weather variations amounting to less than 0.5 [decibar]. At greater depth, the exact surface value becomes relatively less important and subtraction of a fixed value usually suffices. An in-situ taring of barometric pressure is possible with a measurement of the surface pressure using the depth sensor at the surface before deployment. The surface value must then be subtracted for subsequent depth measurements. Care should be taken that the sensor is operationally cooled down to the ocean water and in the orientation of deployment during taring.

References:
Fofonoff, N.P. and R.C.Millard (1983) *Algorithms for Computations of Fundamental Properties of Seawater*, Unesco Technical Papers in Marine Science 44.