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Re-Calibration of Paroscientific Digiquartz Pressure Sensors

Digiquartz sensors are supplied by Paroscientific with coefficients derived from a calibration performed over temperature (0 - 125 °C). When used in the Paroscientific 'temperature model' (as incorporated in Sea-Bird software), these coefficients reflect the initial calibration of the sensor.

Although Paroscientific can re-calibrate the sensors by duplicating the original procedures, the sensor must be removed from the CTD, the cost is relatively high, and lead times can be considerable. Also, Paroscientific no longer has facilities for performing the calibration unless their 'temperature crystal' is in place and active; this requires opening and reworking the sensor itself. It is possible to perform a pressure calibration vs temperature by placing the entire CTD in a temperature-controlled water bath, but of course this is also a cumbersome and expensive operation.

Tests show that room-temperature-derived 'slope' and 'offset' corrections to the initial Digiquartz calibration can account for long-term drift to within less than 0.01% of the sensor's full scale range. To perform this correction, use a suitable dead-weight pressure generator to subject the sensor to increments of known pressures. Run SEASOFT to display pressure, or measure the sensor frequency directly with a counter (or with the CTD Deck Unit) and compute pressure with the formula given on the Digiquartz calibration sheet.

Example

A 10,000 psia sensor has drifted and its responses are low, as shown in the following table:

Pressure (psia)	Indicated Pressure
0	-12.70
2,000	1986.50
4,000	3985.68
6,000	5984.89
8,000	7984.12
10,000	9983.29

A linear regression (best straight-line fit) to the data *[pcorrected = (pindicated * M) + B]* yields M = 1.00039987 and B = 12.710. Seasoft 3.2c (and later) permits entry of these correction coefficients, which were of course originally set to 1.00000000 and 0.000 respectively.

Experimental Derivation of Method

To demonstrate the validity of this approach, two 10,000 psia Digiquartz sensors (S/N 22003 and 22065) were subjected to full re-calibrations at Paroscientific after approximately 4 years of use, with the new calibration results used to predict how the sensors *would have performed* (i.e., what their output frequencies would have been for inputs of 0, 2000, 4000, 6000, 8000, and 10,000 psia) if a simple room-temperature-only calibration had been performed. These frequencies were input to the initial-coefficient model and a linear regression (for a presumed ambient temperature of 20 °C) was used to obtain slope and offset terms for correction of the sensor's calibration drift. To determine if the original temperature models remain valid, this procedure was repeated with the models adjusted for 0 degrees. The results are as follows:

22003	**input p**	**indicated p, 20 °C**	**indicated p, 0 °C**	**error 20 °C**	**error 0 °C**
	0	-21.21	-21.68	-21.21	-21.68
	2000	1977.97	1977.42	-22.03	-22.58
	4000	3977.17	3976.60	-22.83	-23.40
	6000	5976.42	5975.71	-23.58	-24.29
	8000	7975.60	7974.82	-24.40	-25.18
	10000	9974.82	9973.97	-25.18	-26.03

22065	**input p**	**indicated p, 20 °C**	**indicated p, 0 °C**	**error 20 °C**	**error 0 °C**
	0	-12.70	-12.35	-12.70	-12.35
	2000	1986.50	1986.58	-13.50	-13.42
	4000	3985.68	3985.57	-14.32	-14.43
	6000	5984.89	5984.55	-15.11	-15.45
	8000	7984.12	7983.53	-15.88	-16.47
	10000	9983.29	9982.50	-16.71	-17.50

Indicated p, 20 °C: pressure (psia) predicted by new Paroscientific calibration for input p with sensor temperature of 20 °C

Indicated p, 0 °C: pressure (psia) predicted by new Paroscientific calibration for input p with sensor temperature of 0 °C

error, 20 °C: predicted pressure (psia) - input p (psia) at 20 °C

error, 0 °C: predicted pressure (psia) - input p (psia) at 0 °C

Indicated p, 20 °C and input p 0 - 10000 psia in a linear regression generated slope (m) and offset (b) terms for use with the *original* Paroscientific model:

For sensor S/N 22003, m = 1.00039676; b = 21.23044596
For sensor S/N 22065, m = 1.00039999; b = 12.70930197

The following tables show the errors to be expected using the *original* Paroscientific models adjusted for slope and offset errors using the formula 'corrected p = m (indicated p) + b':

22003	**input p**	**corrected p, 20 °C**	**corrected p, 0 °C**	**error 20 °C**	**error 0 °C**
	0	0.02	-0.46	0.02	-0.46
	2000	1999.99	1999.43	-0.01	-0.57
	4000	3999.98	3999.40	-0.02	-0.60
	6000	6000.02	5999.31	0.02	-0.69
	8000	7999.99	7999.21	-0.01	-0.79
	10000	10000.00	9999.16	0.00	-0.84

22065	**input p**	**corrected p, 20 °C**	**corrected p, 0 °C**	**error 20 °C**	**error 0 °C**
	0	0.01	0.36	0.01	0.36
	2000	2000.00	2000.08	0.00	0.08
	4000	3999.98	3999.88	-0.02	-0.12
	6000	6000.00	5999.65	-0.00	-0.35
	8000	8000.02	7999.44	0.02	-0.56
	10000	9999.99	9999.21	-0.01	-0.79

Summary

For the slope/offset corrected data, error 20 °C is clearly insignificant (maximum 0.02 psi or 0.0002% of full scale for either sensor). The original temperature models for the 2 sensors show larger but still modest maximum errors of 0.84 psia (0.0084%) for S/N 22003 and 0.79 psi (0.0079%) for S/N 20065. These errors are of course in each case significantly smaller than the 0.04% calibration accuracy claimed by Paroscientific. Sensor 22003 and 22065 were originally calibrated on 4 April 1985 with re-calibrations performed 2 June 1989 (22003) and 23 December 1988 (22065).