CALIBRATION CERTIFICATE

NAME	:	Fast optical DO sensor for integration
MODEL	:	AROD-FT-CE
SERIAL No.	:	0022
Parameter	:	Temperature Dissolved Oxygen

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Temperature Calibration Certificate

Model	:	AROD-FT-CE
Serial No.	:	0022
Date	:	October 21, 2018
Location	:	Production Section
Method	:	Calibration equation is determined from fifth order regression of samples of the reference temperature against A/D values. Samples are taken at approximately 0, 5, 10, 15, 20, 25, 30, and 35 ℃.

1. Equation

Instrument temperature[℃] = $A+B\times N+C\times N^2+D\times N^3+E\times N^4+F\times N^5$ N: A/D value

2. Coefficients

A =	−1.283571e+01	D =	+6.460353e−13
B =	+1.486590e−03	E =	−8.424089e−18
C =	−2.708129e−08	F =	+5.516658e−23

3. Calibration results

Reference temperature [℃]	A/D value	Instrument temperature [℃]	Residual error [℃]	Acceptance [℃]	OK/NG
0.052	10147	0.052	0.000	±0.005	OK
5.036	14872	5.036	0.000	±0.005	OK
10.039	19977	10.039	0.000	±0.005	OK
15.054	25334	15.054	0.000	±0.005	OK
20.052	30764	20.052	0.000	±0.005	OK
25.070	36168	25.070	0.000	±0.005	OK
30.057	41360	30.057	0.000	±0.005	OK
35.050	46266	35.050	0.000	±0.005	OK

4. Verification

Criteria of judgement : Residual error of the instrument temperature at arbitrary point is within the acceptance value.

Reference temperature [℃]	Instrument temperature [℃]	Residual error [℃]	Acceptance [℃]	Judgement
12.535	12.535	0.000	±0.008	Passed

Examined R Kashida

Approved A. Fukuoka

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Dissolved Oxygen Calibration Certificate (16points) (1/2)

Model : AROD-FT-CE
Serial No. : 0022
Date : October 23, 2018
Location : Production Section
Method : Coefficients are determined by a 16-point calibration (4 temperatures and 4 oxygen concentrations). The 4 oxygen reference standards are produced by saturating the Primary Mixtures with oxygen concentrations of approximately 4%, 10%, 17% and 25%, respectively, which are the National Metrology Institute of Japan (NMIJ) certified traceable gases.
Film No. : 182821BA

1. Equation

$$DO[\mu mol/L] = \left\{\left(\frac{1 + d_0 \times T}{d_1 + d_2 \times N + d_3 \times t + d_4 \times t \times N}\right)^{e_0} - 1\right\} \times \frac{1}{c_0 + c_1 \times T + c_2 \times T^2}$$

T: Temperature[℃] N: (A/D value)/10000 t: LED counter *Uchida et al. (2010)*

2. Pressure compensation

$$DO_{pc}[\mu mol/L] = DO(1 + C_p \times p)$$ p: Pressure[MPa]

3. Coefficients

d0 =	−2.659073e−04	c0 =	+3.164657e−03
d1 =	−1.738292e−01	c1 =	+1.334240e−04
d2 =	+1.852978e−01	c2 =	+2.695398e−06
d3 =	+0.000000e+00	e0 =	+1.000000e+00
d4 =	+0.000000e+00	Cp =	+3.700000e−03

4. Calibration results

Acceptance: ±1.8 μmol/L or ±1.8% of reference value

Condition				A/D Value	Instrument DO [μmol/L]	Residual error [μmol/L]	Acceptance [μmol/L]	Judgement
Temperature [℃]	Air pressure [hPa]	Gas concentration [%]	Reference DO *1 [μmol/L]					
3.024	1021.5	4.007	81.47	51178	80.76	−0.71	±1.80	OK
3.001	1021.6	9.995	203.35	40487	204.37	1.02	±3.66	OK
2.985	1021.4	16.99	345.78	33434	346.23	0.45	±6.22	OK
2.967	1020.7	24.96	507.83	28521	507.04	−0.79	±9.14	OK
10.230	1019.8	4.007	67.88	50036	67.30	−0.58	±1.80	OK
10.223	1019.5	9.995	169.30	39005	169.80	0.50	±3.05	OK
10.230	1019.4	16.99	287.70	31936	288.09	0.39	±5.18	OK
10.200	1019.2	24.96	422.88	27120	423.22	0.34	±7.61	OK
20.007	1019.7	4.007	54.96	48319	54.77	−0.19	±1.80	OK
20.023	1020.0	9.995	137.09	36911	137.32	0.23	±2.47	OK
20.076	1019.8	16.99	232.74	29990	231.57	−1.17	±4.19	OK
20.088	1019.2	24.96	341.64	25328	341.30	−0.34	±6.15	OK
29.831	1017.2	4.007	45.72	46404	46.74	1.02	±1.80	OK
29.857	1016.5	9.995	113.91	35065	113.55	−0.36	±2.05	OK
29.882	1016.2	16.99	193.49	28238	192.41	−1.08	±3.48	OK
29.891	1015.8	24.96	284.11	23740	285.38	1.27	±5.11	OK

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Dissolved Oxygen Calibration Certificate (16points) (2/2)

Model : AROD-FT-CE
Serial No. : 0022
Date : October 23, 2018
Location : Production Section

5. Verification

Criteria of judgement : Each residual error of the instrument DO at 4 arbitrary temperature points is within the acceptance value. The oxygen reference water is produced by saturating the Primary Mixture (oxygen concentration of approximately 21%), the NMIJ certified traceable gas.

Acceptance : ±1.9 μmol/L or ±1.9% of reference value

Condition				Instrument DO [μmol/L]	Residual error [μmol/L]	Acceptance [μmol/L]	Judgement
Temperature [℃]	Air pressure [hPa]	Gas concentration [%]	Reference DO *1 [μmol/L]				
2.980	1021.2	20.98	426.95	426.48	-0.47	±8.11	Passed
10.216	1019.2	20.98	355.32	355.44	0.12	±6.75	Passed
20.076	1019.5	20.98	287.33	286.00	-1.33	±5.46	Passed
29.888	1016.2	20.98	238.91	238.46	-0.45	±4.54	Passed

*1 Garcia and Gordon (1992)

Examined A. Fukuoka

Approved A. Fukuoka

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