



CALIBRATION CERTIFICATE

NAME	: Fast optical DO sensor for integration
MODEL	: AROD-FT-CE
SERIAL No.	: 0021
Parameter	: Temperature Dissolved Oxygen



JFE Advantech Co., Ltd.

Temperature Calibration Certificate

Model : AROD-FT-CE
 Serial No. : 0021
 Date : December 08, 2017
 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 °C.

1. Equation

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

2. Coefficients

A = -1.270396e+01 D = +6.196352e-13
 B = +1.480985e-03 E = -7.899553e-18
 C = -2.647222e-08 F = +5.136310e-23

3. Calibration results

Reference temperature [°C]	A/D value	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	OK/NG
0.030	10023	0.030	0.000	±0.005	OK
5.014	14733	5.014	0.000	±0.005	OK
10.013	19820	10.013	0.000	±0.005	OK
15.059	25201	15.059	0.000	±0.005	OK
20.024	30591	20.024	0.000	±0.005	OK
25.041	35989	25.040	-0.001	±0.005	OK
30.009	41161	30.009	0.000	±0.005	OK
34.987	46056	34.987	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 [°C]	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	Judgement
12.553	12.554	0.001	±0.008	Passed

Examined

R. Koshida

Approved

a. Fukuoka

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

Model : AROD-FT-CE
 Serial No. : 0021
 Date : December 27, 2017
 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. : 172716BA

1. Equation

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

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

2. Pressure compensation

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

3. Coefficients

d0 = -3.292106e-04 c0 = +3.024370e-03
 d1 = -1.335265e-01 c1 = +1.261735e-04
 d2 = +1.884449e-01 c2 = +2.633447e-06
 d3 = +0.000000e+00 e0 = +1.000000e+00
 d4 = +0.000000e+00 Cp = +4.000000e-03

4. Calibration results

Acceptance: $\pm 1.8 \mu\text{mol/L}$ or $\pm 1.8\%$ of reference value

Condition				A/D Value	Instrument DO [$\mu\text{mol/L}$]	Residual error [$\mu\text{mol/L}$]	Acceptance [$\mu\text{mol/L}$]	Judgement
Temperature [°C]	Air pressure [hPa]	Gas concentration [%]	Reference DO *1 [$\mu\text{mol/L}$]					
2.899	1014.9	4.009	81.26	48716	80.15	-1.11	± 1.80	OK
2.869	1015.1	10.06	204.10	38292	205.07	0.97	± 3.67	OK
2.835	1014.6	17.11	347.30	31375	347.53	0.23	± 6.25	OK
2.786	1014.2	24.99	507.72	26562	507.05	-0.67	± 9.14	OK
10.139	1014.1	4.009	67.68	47482	67.60	-0.08	± 1.80	OK
10.138	1014.0	10.06	169.83	36771	170.88	1.05	± 3.06	OK
10.122	1014.3	17.11	289.03	29841	289.69	0.66	± 5.20	OK
10.118	1015.0	24.99	422.48	25123	422.74	0.26	± 7.60	OK
19.946	1016.8	4.009	54.90	45770	55.06	0.16	± 1.80	OK
19.936	1017.5	10.06	137.88	34729	137.72	-0.16	± 2.48	OK
19.974	1017.8	17.11	234.42	27856	233.21	-1.21	± 4.22	OK
20.136	1018.5	24.99	341.49	23259	340.63	-0.86	± 6.15	OK
29.970	1016.8	4.009	45.62	44041	45.99	0.37	± 1.80	OK
29.979	1017.1	10.06	114.48	32766	114.02	-0.46	± 2.06	OK
29.966	1017.6	17.11	194.85	25994	193.98	-0.87	± 3.51	OK
29.980	1019.1	24.99	284.94	21565	286.55	1.61	± 5.13	OK

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

Model : AROD-FT-CE
 Serial No. : 0021
 Date : December 27, 2017
 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: $\pm 1.9 \mu\text{ mol/L}$ or $\pm 1.9\%$ of reference value

Temperature [°C]	Condition			Instrument DO [$\mu\text{ mol/L}$]	Residual error [$\mu\text{ mol/L}$]	Acceptance [$\mu\text{ mol/L}$]	Judgement
	Air pressure [hPa]	Gas concentration [%]	Reference DO *1 [$\mu\text{ mol/L}$]				
2.812	1014.5	20.98	426.06	426.30	0.24	± 8.10	Passed
10.124	1014.8	20.98	354.57	355.21	0.64	± 6.74	Passed
20.059	1018.2	20.98	287.05	285.86	-1.19	± 5.45	Passed
29.983	1018.1	20.98	238.96	238.97	0.01	± 4.54	Passed

*1 Garcia and Gordon (1992)

Examined A. FukuoKa
 Approved A. FukuoKa