



CALIBRATION CERTIFICATE

NAME	: Fast optical DO sensor for integration
MODEL	: AROD-FT-CE
SERIAL No.	: 0049
Parameter	: Temperature Dissolved Oxygen



JFE Advantech Co., Ltd.

Temperature Calibration Certificate

Model : AROD-FT-CE
 Serial No. : 0049
 Date : March 12, 2022
 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

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

2. Coefficients

A = -1.281850e+01 D = +6.146663e-13
 B = +1.478456e-03 E = -7.810475e-18
 C = -2.634094e-08 F = +5.076320e-23

3. Calibration results

Reference temperature [°C]	A/D value	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	OK/NG
0.017	10130	0.017	0.000	±0.005	OK
4.991	14844	4.991	0.000	±0.005	OK
9.963	19913	9.961	-0.002	±0.005	OK
15.034	25332	15.036	0.002	±0.005	OK
19.974	30699	19.975	0.001	±0.005	OK
24.994	36102	24.993	-0.001	±0.005	OK
29.983	41295	29.983	0.000	±0.005	OK
34.957	46180	34.956	-0.001	±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
12.570	12.567	-0.003	±0.008	Passed

Examined T. KIKUCHI
 Approved M. Ujinaki

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

Model : AROD-FT-CE
 Serial No. : 0049
 Date : March 19, 2022
 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. : 211042BA

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 = +3.175516e-04 c0 = +3.172562e-03
 d1 = -1.552496e-01 c1 = +1.356167e-04
 d2 = +1.864452e-01 c2 = +2.997073e-06
 d3 = +0.000000e+00 e0 = +1.000000e+00
 d4 = +0.000000e+00 Cp = +4.200000e-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 [$\mu\text{mol/L}$]					
0.805	999.6	4.005	84.68	50494	82.92	-1.76	± 1.80	OK
0.778	999.6	10.00	211.59	39901	213.16	1.57	± 3.81	OK
0.759	998.8	17.09	361.52	32850	362.40	0.88	± 6.51	OK
0.741	1000.4	25.04	530.81	27947	529.61	-1.20	± 9.55	OK
9.984	1002.3	4.005	67.08	48973	67.09	0.01	± 1.80	OK
9.998	1003.2	10.00	167.58	37959	168.96	1.38	± 3.02	OK
9.994	1003.7	17.09	286.56	30881	287.04	0.48	± 5.16	OK
9.961	1002.6	25.04	419.73	26109	420.21	0.48	± 7.56	OK
19.856	1002.0	4.005	54.15	47369	54.27	0.12	± 1.80	OK
19.893	1001.8	10.00	135.07	35994	134.75	-0.32	± 2.43	OK
19.924	1002.2	17.09	230.79	28953	228.87	-1.92	± 4.15	OK
19.939	1003.2	25.04	338.40	24273	337.41	-0.99	± 6.09	OK
29.803	1004.0	4.005	45.13	45632	45.70	0.57	± 1.80	OK
29.798	1004.9	10.00	112.79	33983	112.44	-0.35	± 2.03	OK
29.812	1006.5	17.09	193.02	27039	191.66	-1.36	± 3.47	OK
29.828	1007.9	25.04	283.11	22497	285.39	2.28	± 5.10	OK

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

Model : AROD-FT-CE
 Serial No. : 0049
 Date : March 19, 2022
 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

Condition				Instrument DO [$\mu \text{ mol/L}$]	Residual error [$\mu \text{ mol/L}$]	Acceptance [$\mu \text{ mol/L}$]	Judgement
Temperature [$^{\circ}\text{C}$]	Air pressure [hPa]	Gas concentration [%]	Reference DO *1 [$\mu \text{ mol/L}$]				
0.755	999.8	21.06	446.01	446.03	0.02	± 8.47	Passed
9.972	1002.8	21.06	353.01	353.45	0.44	± 6.71	Passed
19.938	1003.3	21.06	284.63	282.84	-1.79	± 5.41	Passed
29.803	1006.9	21.06	238.00	237.91	-0.09	± 4.52	Passed

*1 Garcia and Gordon (1992)

Examined M. Ujinaki
 Approved M. Ujinaki