



CALIBRATION CERTIFICATE

NAME	: Fast optical DO sensor for integration
MODEL	: AROD-FT-CE
SERIAL No.	: 0054
Parameter	: Temperature Dissolved Oxygen



JFE Advantech Co., Ltd.

Temperature Calibration Certificate

Model : AROD-FT-CE
 Serial No. : 0054
 Date : November 01, 2021
 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
 Instrument temperature[°C] = $A+B \times N+C \times N^2+D \times N^3+E \times N^4+F \times N^5$ N: A/D value

2. Coefficients

A =	-1.321663e+01	D =	+5.776332e-13
B =	+1.465867e-03	E =	-7.117026e-18
C =	-2.541269e-08	F =	+4.582096e-23

3. Calibration results

Reference temperature [°C]	A/D value	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	OK/NG
0.208	10726	0.208	0.000	±0.005	OK
5.143	15462	5.142	-0.001	±0.005	OK
10.089	20554	10.090	0.001	±0.005	OK
15.153	25990	15.152	-0.001	±0.005	OK
20.065	31341	20.065	0.000	±0.005	OK
25.041	36696	25.041	0.000	±0.005	OK
29.988	41826	29.987	-0.001	±0.005	OK
34.926	46654	34.926	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
12.687	12.687	0.000	±0.008	Passed

Examined T. KIKUCHI
 Approved M. Ujinaki

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

Model : AROD-FT-CE
 Serial No. : 0054
 Date : November 03, 2021
 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. : 201239BA

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 = +1.255222e-04 c0 = +2.912402e-03
 d1 = -1.544663e-01 c1 = +1.262973e-04
 d2 = +1.892410e-01 c2 = +2.710603e-06
 d3 = +0.000000e+00 e0 = +1.000000e+00
 d4 = +0.000000e+00 Cp = +4.100000e-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 [$\mu\text{mol/L}$]					
0.687	1016.1	4.001	86.27	50306	84.65	-1.62	± 1.80	OK
0.672	1016.1	10.03	216.35	40138	217.69	1.34	± 3.89	OK
0.641	1016.1	17.03	367.69	33279	368.71	1.02	± 6.62	OK
0.641	1015.7	24.96	538.65	28416	537.42	-1.23	± 9.70	OK
9.973	1014.8	4.001	67.86	48827	67.79	-0.07	± 1.80	OK
9.967	1014.5	10.03	170.09	38213	171.30	1.21	± 3.06	OK
9.967	1015.0	17.03	288.92	31313	289.48	0.56	± 5.20	OK
9.965	1015.6	24.96	423.75	26510	424.25	0.50	± 7.63	OK
19.898	1015.4	4.001	54.77	47156	55.17	0.40	± 1.80	OK
19.918	1014.8	10.03	137.16	36202	136.74	-0.42	± 2.47	OK
19.901	1013.5	17.03	232.67	29346	230.91	-1.76	± 4.19	OK
19.909	1012.6	24.96	340.64	24679	339.53	-1.11	± 6.13	OK
29.685	1013.0	4.001	45.58	45602	46.04	0.46	± 1.80	OK
29.667	1013.9	10.03	114.40	34279	113.97	-0.43	± 2.06	OK
29.668	1014.6	17.03	194.36	27475	193.07	-1.29	± 3.50	OK
29.752	1015.1	24.96	284.61	22888	286.89	2.28	± 5.12	OK

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

Model : AROD-FT-CE
 Serial No. : 0054
 Date : November 03, 2021
 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 [$\mu\text{mol/L}$]				
0.637	1016.0	21.04	454.27	454.30	0.03	± 8.63	Passed
9.966	1015.0	21.04	357.00	357.43	0.43	± 6.78	Passed
19.903	1012.9	21.04	287.26	285.74	-1.52	± 5.46	Passed
29.713	1014.8	21.04	239.99	239.84	-0.15	± 4.56	Passed

*1 Garcia and Gordon (1992)

Examined M. TAKEISHI
 Approved M. Ujinaki