

Operation Manual

Fast optical DO sensor for microscale measurements

RINKO EC

Models	ARO-EC
	ARO-EC-CM-CE

CE

For safe use

1. Use after thoroughly reading this manual.
2. Improper use can lead to accidents.
3. Safely keep this manual in order not to lose it.



JFE Advantech Co., Ltd.

JFE

Introduction

- RINKO EC (model name: ARO-EC) is an extremely fast-response sensor for microscale measurements of water temperature and dissolved oxygen (hereinafter, DO).
- ARO-EC is suitable for aquatic eddy covariance measurements of temperature and DO.
- ARO-EC outputs 0 – 5 V analog and is integrated easily with other loggers/instruments such as Nortek Vector.
- DO sensing foil can be replaced easily by users (optional).

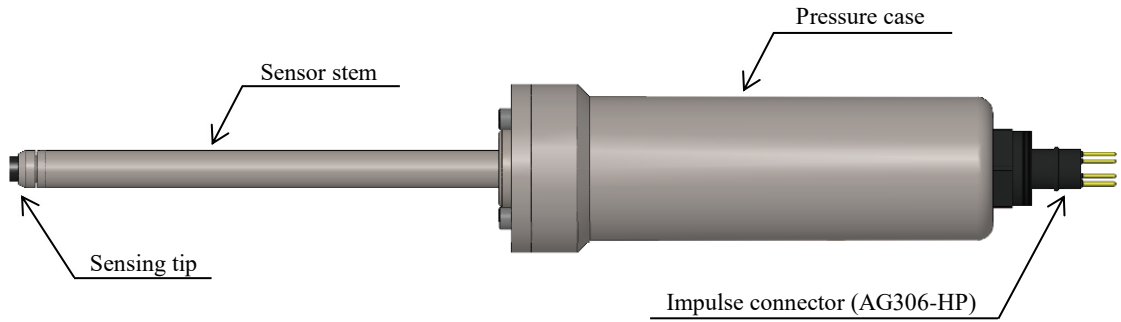
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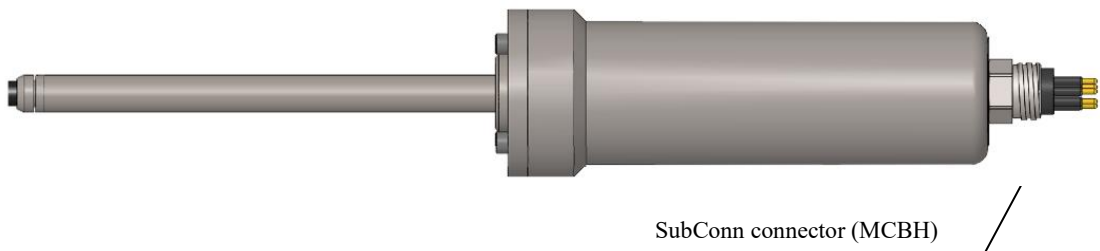
1 Part Names

1.1 Main body

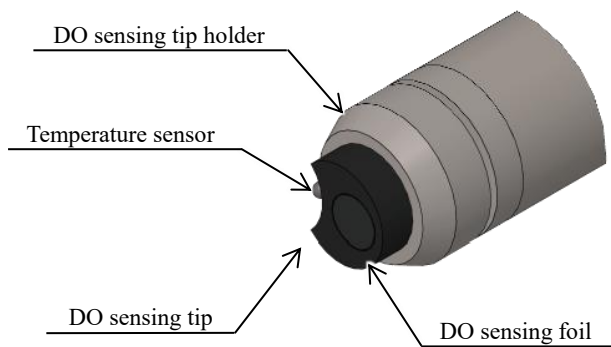
ARO-EC



ARO-EC-CM-CE








1.2 Sensing tip



2 Package Contents

(1) Basic package ⁽¹⁾


No.	Name		Quantity
1	ARO-EC main body (w/ dummy plug) ⁽²⁾		1
2	Protection cap		1
3	Air sparging set ⁽³⁾		1
4	User's Manual (this manual)		1
5	Calibration certificate		1

Note ⁽¹⁾: The above list indicates the basic package. The content may differ depending on the order.

Note ⁽²⁾: Cable is not included. Please prepare an appropriate cable.






Note ⁽³⁾: Air sparging set is not included on the package directed to countries that request CE marking.

(2) Optional parts

No.	Name		Quantity
1	DO sensing tip		1

3 Safety Warning

Make Sure to Read This Before Use

 DANGER	Indicates limited cases (including highly dangerous cases), which may cause death or serious injury to users, and have high degree of emergency (degree of imminence) when dangerous situations occur.
 WARNING	Indicates cases, which may cause death or serious injury to users.
 CAUTION	Indicates cases, which may cause minor injury to users or material damage.
	Indicates general precautions.
	Indicates supplements to control method and convenient functions.

DANGER

- **Ensure safety for operations on water or ships.**

WARNING

- **Do not modify.**
- **Do not use it with a power supply beyond the rated values.**
- **Do not disassemble.**
It can cause fire or electrocution.
- **Do not directly look at the excitation light for a long time.**
It can damage the eyes.



CAUTION

- **Do not apply strong force or impact on the sensor.**
It can lead to damage, which may cause injury and seeping of water into the instrument.
- **Make sure to insert the connector up to the base.**
- **Do not leave the instrument in a place with high temperature (e.g. under direct sunlight) for a long time.**
It can accelerate the degradation of the DO sensing foil.

4 Precautions for Usage

4.1 Use of instrument

- (1) This is a group 1, class B product according to EN 55011 (CISPR 11).

This means that this product does not generate and/or use intentionally radio-frequency energy, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material or inspection / analysis purpose and that it is suitable for use in domestic establishments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

- (2) After every use, clean with fresh water, take away the moisture with a soft cloth, and store securely.

- (3) Please do not touch the temperature sensor directly. It may damage the sensor.

Static electricity may damage the parts used for this instrument.

Take countermeasures to prevent damage from static electricity during maintenance and others since it may damage the instrument.

- (4) The DO sensing foil is highly delicate and requires handling with care. Significant damage causes inaccurate data and requires a replacement of the DO sensing foil.

- (5) When not in use, place the protection cap.

- (6) Do not drop the instrument or apply impact.

- (7) Before touching the instrument, release static electricity by touching a metal.

- (8) For storage location, avoid places with temperature below -5 °C, over 40 °C, high humidity, or high amount of dust.

- (9) If the instrument is not used for a long time, inspect each part before connecting to the power supply.

- (10) When using the instrument in water, it is recommended to use it at 30 °C or below. When it is used in water at 30 °C or above, the tracking for correction of temperature change can slow down, requiring more time to resume to the normal value.

- (11) Use cables included with the instrument or specified cables only, and follow the use method specified in the manual when deploying the instrument. Using this instrument in any way not described in this manual may reduce the effectiveness of the instrument's protective functions.

In case of replacing any parts and/or consumables, please make sure to use those specified by our company. Please feel free to contact us with any questions.

Cable list for ARO-EC

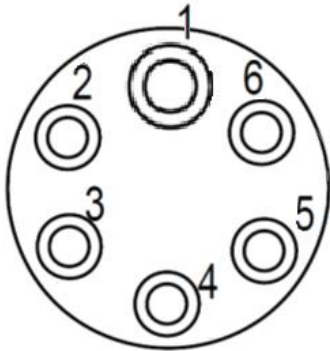
No.	Interface	Max.Cable Length, Shielding	Cable Classification
1	DC Input/ Signal Port	1.5m, Un-Shielded	Signal and DC Power Line

4.2 Disposal

Please follow your local laws and regulations when disposing.

5 Pin Configuration

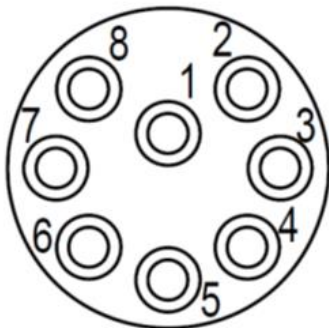
5.1 AG306-HP connector (Teledyne Impulse)



Impulse AG306-HP

1	GND
2	Analog OUT 1 (DO, 0 to 5 V)
3	S. GND 1
4	Analog OUT 2 (Temperature, 0 to 5 V)
5	S. GND 2
6	POW+ (10 to 24 VDC, 12 VDC recommended)

5.2 MCBH (WB) 8 pin connector (SubConn)



SubConn MCBH(WB) 8-pin

1	Analog OUT2 + (Temperature, 0 to 5 V)
2	(not used)
3	(not used)
4	Analog OUT 2 - (Temperature, 0 to 5 V)
5	Analog OUT 1 - (DO, 0 to 5 V)
6	Analog OUT 1 + (DO, 0 to 5 V)
7	GND
8	POW+ (10 to 24 VDC, 12 VDC recommended)

6 Maintenance and Inspection

6.1 Before use

- (1) Check that the sensor surface is free of any foreign object.
- (2) Check that there is no loose or damaged connector or screw.
- (3) Span/zero calibration is recommended before use.
- (4) Make sure to remove the protection cap before use.
- (5) Please retighten the tip holder by hand.

6.2 Maintenance after use

- (1) After use, clean well with fresh water. If something cannot be removed by water, gently remove it with a soft cloth. Rubbing it hard can damage the DO sensing foil.
- (2) After water cleaning, remove the moisture either by an air blower or by wiping with a soft cloth.
- (3) Check if there is no scratch or damage on the sensor.

6.3 Storage

- (1) For storing, avoid places with high temperature, high humidity, or direct sunlight.
- (2) Place the sensor protection cap when storing in order to protect the sensor and prevent degradation.
- (3) Avoid places with temperature higher than 40 °C as it can cause output error or degradation of the DO sensing foil.

7 Calculation of Physical Values

7.1 Temperature calculation

Temperature physical value (t) in °C is calculated from the equation below:

$$t = A + B \times N + C \times N^2 + D \times N^3$$

t : Temperature [°C]

A, B, C, D : Calibration coefficients presented in calibration certificate

N : Instrument output [0 – 5 V]

7.2 Oxygen calculation

DO physical value (P) in % is calculated from the equation below:

$$P' = \frac{A}{1 + D(t - 25) + F(t - 25)^2} + \frac{B}{N\{1 + D(t - 25) + F(t - 25)^2\} + C}$$

$$P = G + H \times P'$$

P : Dissolved oxygen [%]

A, B, C, D, F : Calibration coefficients presented in calibration certificate

G, H : Coefficients updated by span/zero calibration (see Chapter 8)

t : Temperature [°C]

N : Instrument output [0 – 5 V]

The pressure-compensated oxygen (P_d) in % is calculated from the equation below:

$$P_d = P(1 + E \times d)$$

P_d : Pressure-compensated dissolved oxygen [%]

d : In situ pressure (atmosphere + water pressure) [MPa]

E : Calibration coefficient presented in calibration certificate

8 Span/Zero Calibration

Span/zero calibration is recommended before each measurement to obtain accurate oxygen data. This calibration updates the coefficients G and H . Please note that the coefficients $A - F$ are provided by manufacturer and not updated by users.

8.1 How to measure the 100% and 0% DO data

Calibration procedure is described below:

- ① Prepare the instrument and connect it to your logger/instrument having an analog in/out, such as Nortek Vector.
- ② Prepare air-sparged water (see 8.1.1) and a sodium sulfite solution (see 8.1.2).
- ③ Start the measurement by operating your logger/instrument.
- ④ Span calibration: Place the DO sensor in air-sparged water and wait for seconds to record the data in your logger/instrument.



Air-sparged water

- ⑤ Zero calibration: Place the DO sensor in a sodium sulfite solution and record the data in the same way. Measure while gently turning the instrument so as not to make bubbles. Place the tip of the sensor approximately 3 cm above the bottom. Do not return to the span calibration because the DO will be contaminated by the residual sodium sulfite solution.



Sodium sulfite solution

- ⑥ Stop the measurement by operating your logger/instrument.



- Carry out this process with care as it affects physical quantities.
- Make sure to complete the span calibration first.
- Consider replacing the DO sensing foil if the value is not calibrated.

8.1.1 How to make air-sparged water for span calibration

Air-sparged water (Air-saturated water)	Sparge air into 500 mL of water while stirring for more than 30 minutes. Stir well during sparging (using a stirrer is recommended).
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8.1.2 How to make sodium sulfite solution for zero calibration

Make the sodium sulfite solution (referred to as Na_2SO_3 solution) for zero calibration by the following process. Please note that JFE Advantech does not provide a sodium sulfite outside Japan, so please prepare it by yourself.

Na_2SO_3 solution	Dissolve 25 g of sodium sulfite in 500 mL of water.
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Caution

- If Na_2SO_3 solution enters eyes or mouth, immediately stop the operation and apply appropriate treatment according to the Safety Data Sheet (SDS).
- If Na_2SO_3 solution touches the skin, immediately wash it off with large amount of water.
- When disposing used solutions, do so appropriately according to the SDS.

8.2 How to update the coefficients G and H

Atmosphere pressure is required to update the coefficients G and H.

8.2.1 Calculation of DO physical values at 100% and 0% DO

Calculation procedure is described below:

- ① Retrieve the recorded voltage data (temperature and DO) from your logger/instrument. Confirm if the voltage data are stable during each measurement (DO 100% and DO 0%).
- ② Determine the representative voltage of each measurement for the following calculation. Averaging would be reasonable. Now, 4 voltage values are prepared, i.e., temperature and DO voltages during DO 100% and 0% measurements.
- ③ Calculate the temperature physical values [$^{\circ}\text{C}$] of both DO 100% water (air-sparged water) and DO 0% water (sodium sulfite solution) from the temperature voltages by following the equation in Section 7.1 or the calibration certificate.
- ④ Calculate the DO physical values in % for DO 100% (P_1) and DO 0% (P_0) from the DO voltages and the temperature physical values calculated in ③. The equation is described in Section 7.2.

8.2.2 Calculation of coefficients G and H

Calculation procedure is described below:

- ① Calculate the oxygen saturation level (O_{sat}) in the water.

$$O_{\text{sat}} = \frac{p - p_v}{1013.25 - p_v} \times 100$$

O_{sat} : Oxygen saturation level [%]

p : Atmospheric pressure [hPa]

p_v : Saturation vapor pressure [hPa]

$$p_v = 6.11 \times 10^{\frac{7.5 \times t}{237.3 + t}}$$

t : Water temperature [°C]

- ② Calculate the new coefficients G and H .

$$G = \frac{G' - P_0}{P_1 - P_0} \times O_{\text{sat}}$$

$$H = \frac{O_{\text{sat}}}{P_1 - P_0} \times H'$$

G, H : New coefficients

G', H' : Current coefficients used for calculating P_1 and P_0

P_1 : DO physical value in DO 100% water [%]

P_0 : DO physical value in DO 0% water [%]



- Verify DO data calculated by new coefficients G and H .

9 DO Sensing Foil Replacement (optional)

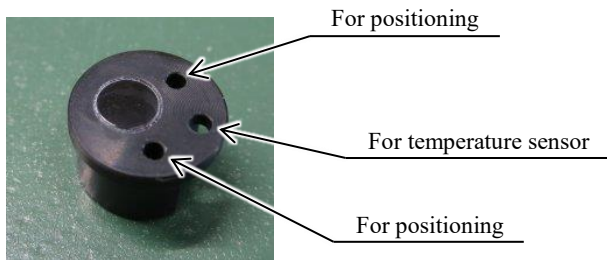
Replacement of the DO sensing foil is required if the DO data noise is significantly increased compared to previous measurements. It is recommended to replace the DO foil every accumulated 200 hours of operation. After the replacement, it is strongly recommended to perform the span/zero calibration (see Chapter 8).

9.1 How to replace the new DO sensing foil

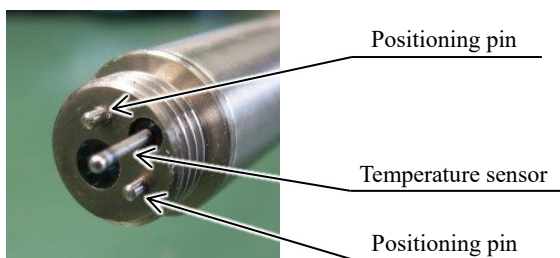
- (1) Detach the DO sensing tip from the sensor stem by unscrewing the DO sensing tip holder by hand.



- (2) Attach the new DO sensing tip to the sensor stem. DO sensing tip has 3 holes; 2 holes for positioning 1 hole for temperature sensor. Carry out this process with care not to bend the temperature sensor.



DO sensing tip (bottom face)



Sensor stem



Sensor stem with the DO sensing tip

- (3) Fix the DO sensing tip by screwing the DO sensing tip holder by hand.



- DO NOT USE tools such as pliers for screwing/unscrewing the DO sensing tip holder.
- Carry out this process with care as the temperature sensor is installed loosely.
- Loose temperature sensor does not affect the measurement or waterproofing.

10 Troubleshooting

Problem	Action
Cannot output 0 – 5 V analog	<ul style="list-style-type: none">➔ Check if the power voltage received by ARO-EC is between 10 and 24 VDC.➔ Check the connection of the connectors.➔ Check if the pin configuration of the cable is correct.
The measured value is unstable	<ul style="list-style-type: none">➔ If something is attached on the sensor (e.g., bio-fouling), clean it by running water or a soft cloth. See Chapter 6.➔ Check if a strong noise source is in contact with the main body or the lead wire.➔ Check if there is any large scratch on the DO sensing foil.➔ Try span/zero calibration. See Chapter 8.

11 Specifications

11.1 Instrument specifications

Item	Specification
Power	10 to 24 VDC (12 VDC recommended) ⁽¹⁾
Current drain (at 12 VDC)	20 mA (typical)
Signal output	0 to 5 V analog
Pre-heat time	5 s
Depth rating	50 m
Material	Housing: Titanium (grade 2)
Connector	AG306-HP (Impulse Technologies Inc.)
Weight	Approx. 0.6 kg in air, 0.3 kg in water

Note ⁽¹⁾: Receiving voltage on ARO-EC side. Voltage may decrease in cable connecting ARO-EC with other instrument/logger depending on the type and length of the cable in use.

11.2 Sensor specifications

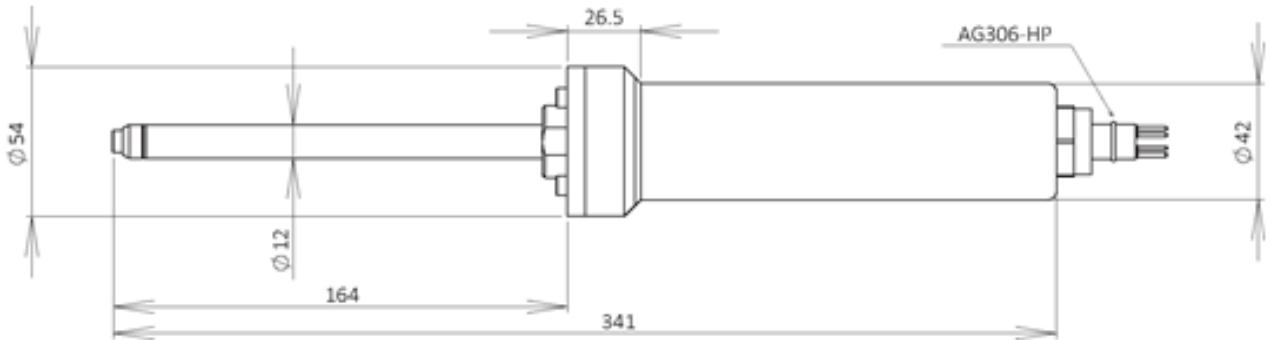
Item	Temperature	DO
Measurement principle	Thermistor	Phosphorescence
Measurement range	-3 to 45 °C	Air saturation: 0 to 200%
Calibration range	3 to 31 °C	Air saturation: 0 to 200%
Repeatability	–	Air saturation: ±2%
Accuracy	±0.02 °C	–
Response time (90%)	< 0.5 s	< 0.5 s ⁽²⁾
Life-time	–	200 h in continuous operation

Note ⁽²⁾: From air to water at 25 °C. At low temperatures the response time will be slower.

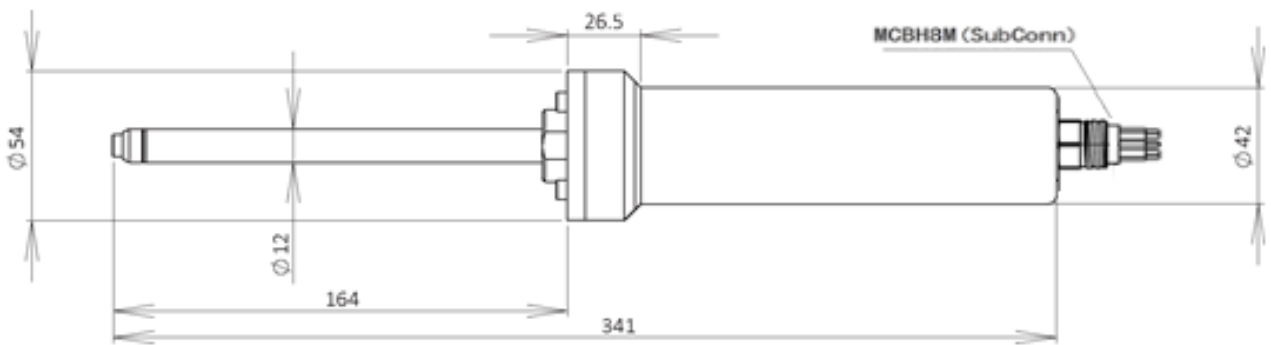
11.3 Drawings

ARO-EC

Dimensions are in mm.



ARO-EC-CM-CE



12 Warranty

The warranty is provided for this product.

- (1) The warranty period is defined to be **1 year** after the delivery of the product. During this period, if the problem is considered to be a design or manufacturing defect, or malfunction upon a normal condition, JFE Advantech will repair the product free of charge.
- (2) Scratches, stain, rust etc. on accessories, expendables, package, and exterior are out of warranty.
- (3) Note that fees are applied in the cases listed below even within the warranty period.
 - a. Damage during installment, mooring, and storage
 - b. Malfunction and damage caused by wrong operation or carelessness
 - c. Malfunction and damage caused by improper repair and modification by a third party
 - d. Malfunction and damage caused by shipment, fall, and impact after purchase
 - e. Malfunction and damage due to external causes such as fire, earthquake, flood, lightening, other natural disasters, public nuisance, abnormal voltage, corrosive gas, organic solvent, and chemical solution
 - f. Malfunction and damage caused by abnormality in other devices connected to the product
 - g. For replacing the expendables
 - h. Malfunction and damage caused by replacement of the expendables done by users (e.g. O-ring and wiper blade)
 - i. Malfunction and damage caused by a third party's product such as equipment and software
- (4) Note that JFE Advantech will not be held liable for damage caused by the use of the product, lost profit, or any claim by a third party.
- (5) Damage during installment or shipment is out of warranty. Consider obtaining insurance if such damage is of concern.
- (6) In case of repair, the warranty period is defined to be **half year** after the delivery of the repaired product. During this period, if the same problem happens again upon a normal condition, JFE Advantech will repair the product free of charge.



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