



TYPE APPROVAL CERTIFICATE

Certificate No:
TAP00001VF
Revision No:
2

This is to certify:

That the **Ballast Water Management System**

with type designation(s)
Blue Ocean Shield BWMS, model range BOS100(Ex) - BOS3200(Ex)

Issued to

COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.
Weihai,, Shandong, China

is found to comply with

IMO Resolution MEPC.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)
DNV rules for classification – Ships Pt.6 Ch.7 Sec.1 Ballast water management – BWM
DNV class programme DNV-CP-0209 – Type approval – Ballast water management systems
DNV class guideline DNV-CG-0339 – Environmental test specification for electrical, electronic and programmable equipment and systems

Application :

This is to certify that the Ballast Water Management System listed above has been examined and tested in accordance with the requirements of the specifications contained in Resolution MEPC.300(72) and DNV Rules stated above. This Certificate is valid only for the Ballast Water Management System referred to above.

System Design Limitations / Limiting Operating Conditions imposed are described in this document.

For the compliance with the resolution MEPC.300(72), the Certificate is issued on behalf of the Norwegian Maritime Authority.

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV, unless otherwise instructed by relevant Maritime Administrations.

Issued at **Høvik** on **2022-06-13**

This Certificate is valid until **2024-07-04**.

DNV local station: **Dalian NB & CMC**

Approval Engineer: **Wenjun Wu**



for **DNV**

Digitally Signed By: **Sæle-Nilsen, Dag**

Location: **DNV Høvik, Norway**

Dag Sæle-Nilsen
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.



Form code: TA 251

Revision: 2021-03

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Page 1 of 13

Name of ballast water management system (BWMS)

BLUE OCEAN SHIELD BWMS

Ballast water management system manufactured and owned by

COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.

Place of production

COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd., Weihai, China

Type and model designations

BLUE OCEAN SHIELD BWMS Ballast Water Management System (BWMS) BOS100(Ex), BOS200(Ex), BOS300(Ex), BOS500(Ex), BOS700(Ex), BOS900(Ex), BOS1200(Ex), BOS1600(Ex), BOS2400(Ex), BOS3200(Ex)

Equipment / Assembly drawings

Type	Description	Drawing no.	Rev.
Piping and instrumentation diagram (P&ID)	P&ID (Drawing within OMSM Annex 4)	PID-2019-00	Rev.13
	P&ID (Drawing within OMSM Ex Annex 4)	PIDEx-2019-00	Rev.02
Assembly drawing	General Arrangement Drawing/Assemble Drawing (Drawing within OMSM Annex 2/3)	BOS-AD-01 to 04 & BOS-AD-BW4 01 to 04	Rev.3
	General Arrangement Drawing/Assemble Drawing (Drawing within OMSM Ex Annex 2/3)	BOS-AD-01 to 04 & BOS-AD-BW4 01 to 04	Rev.03
General Arrangement Drawings	General Arrangement Drawing (Drawing within OMSM Annex 2/3)	SL-2019-00	Rev.3
	General Arrangement Drawing (Drawing within OMSM Ex Annex 2/3)	GAEx-2019-00	Rev.03
Drawings of components	General Arrangement Drawing (Drawing within OMSM Annex 2/3)	SL-2019-00	Rev.3
	General Arrangement Drawing (Drawing within OMSM Ex Annex 2/3)	GAEx-2019-00	Rev.03
Electrical schematic diagram	Electrical Schematic Diagram of BLUE OCEAN SHIELD (BOS) BWMS (OMSM Annex 5)	BOS-ES-00	Rev.1
	Electrical Schematic Diagram of BLUE OCEAN SHIELD (BOS) BWMS (OMSM Ex Annex 5)	BOS-ESEx-00	Rev.01
Equipment list	Bill of Materials of BLUE OCEAN SHIELD (BOS) BWMS (OMSM Annex 1)	BOM-2016-00	Rev.15

Type	Description	Drawing no.	Rev.
	Bill of Materials of BLUE OCEAN SHIELD (BOS) BWMS (OMSM Ex Annex 1)	BOMEx-2019-00	Rev.05

Treatment Rated Capacity

100 – 3200 m³/h

Product description

Treatment sequence:

- Ballast water uptake: Filtration & UV inactivation
- Ballast water discharge: UV inactivation

After ballasting or de-ballasting operation, the system shall be cleaned using the systems Cleaning in Place (CIP) function. Cleaning Liquid: DREWCLEAN 2010.

System design limitations / Water quality parameters

Temperature and Salinity

Temperature and salinity of the ballast water are not limiting conditions for the BOS BWMS.

System design limitations / Operational parameters

Holding time

The BWMS has demonstrated performance to the discharge standard in land-based testing with a minimum holding time between intake and discharge of 2 hours in all water salinities. UV treatment is instant and does not require any hold time in a ballast tank to render organisms inviable. Therefore, holding time is not found to be a limiting condition for the ballast water management system.

UV Fraction

UV Fraction (UVF) is calculated based on measured UV intensity. The BWMS has demonstrated performance to the discharge standard when operating with the UVF of inlet water not less than 50% during the ballast water uptake.

Treatment Rated Capacity (TRC) of the BWMS

The Treatment Rated Capacities (TRC) of the designated BLUE OCEAN SHIELD BWMS models are listed below. The list also specifies the major components of the BLUE OCEAN SHIELD BWMS that shall be installed for a specific BLUE OCEAN SHIELD BWMS model.

The BWMS has a flow control function according to measured UV Fraction (UVF) of inlet water by a flow control valve after UV reactor to ensure that flow rates are kept within the TRC of a specific model. The BWMS starts flow reduction at UVF 70%. An UVF low alarm will be triggered and logged when operating with UVF<50%.

The BOS BWMS applies parallel installation of UV reactors for BOS2400 and BOS3200 model with one corresponding filter, dedicated flowmeter between filter and each UV reactor and flow control valve after each UV reactor.

Model	TRC (m ³ /h)	Filter	UV reactor
BOS100(Ex)	100	FH100(Ex)	UV100(Ex)
BOS200(Ex)	200	FH200(Ex)	UV200(Ex)
BOS300(Ex)	300	FH300(Ex)	UV300(Ex)
BOS500(Ex)	500	FH500(Ex)	UV500(Ex)
BOS700(Ex)	700	FH700(Ex)	UV700(Ex)
BOS900(Ex)	900	FH900(Ex)	UV900(Ex)
BOS1200(Ex)	1200	FH1200(Ex)	UV1200(Ex)
BOS1200(Ex)	1200	FH1250(Ex)	UV1200(Ex)
BOS1600(Ex)	1600	FH1600(Ex)	UV1600(Ex)
BOS1600(Ex)	1600	FH1650(Ex)	UV1600(Ex)
BOS2400(Ex)	2400	FH2400(Ex)	2x UV1200(Ex)
BOS3200(Ex)	3200	FH3200(Ex)	2x UV1600(Ex)

Pressure

The minimum/maximum system operating pressure and the differential pressure triggering backflushing are listed below.

Model	Minimum filter inlet pressure (bar)	Maximum working pressure (bar)	Differential pressure triggering backflushing (bar)
BOS100 – BOS3200	1.5	7	Continuous back-flush

The BOS BWMS filter and UV unit are defined as Pressure Vessel Class III.

Control and monitoring equipment

Software version

The BOS BWMS is type approved with the system control software version V2.0.0.xx (where xx shall be 0 or higher). Any changes to the software are to be recorded as long as the BWMS is in use onboard. The records of all changes are to be forwarded to DNV for evaluation. Major changes in the software, which can alter the performance of the system, require approval. Testing of the application functions of the revised software may be required.

Safety measures

The BWMS is type approved with the following instruments related to safety:

- Flow meter (installed after filter unit)
- Two temperature sensors (mounted in UV unit)
- A pressure transmitter (mounted in UV unit)
- A pressure relief valve mounted at connected pipe to UV unit, with opening at 7.7 bar

Electrical and electronic components

The type approved BWMS shall include the following control and monitoring equipment (including the above listed instruments related to safety) indicated on the P&ID (PID-2019-00/PIDEx-2019-00) and specified on the component lists (BOM-2016-00/BOMEx-2019-00). Except for the components listed below, alternate models to the ones specified on the component lists may be used provided that information regarding the selected components is part of the documentation related to the specific installation, by providing either a reference to a valid type approval certificate or technical documentation demonstrating that the selected component was subject to environmental testing as per IACS UR E10.

For the following electrical and electronic components only the models specified in the component lists shall be used:

Name	Manufacturer	Model
Control system box	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	CSB5/ECSB1
Control system junction box (Ex-models)	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	JXB
Remote control system box	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	RCSB1
UV control cupboard	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	BEA
UV power cupboard	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	BEB
Filter control box	COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	F-E01/EF-E01
Light intensity transmitter	HAISEN TECHNIK CO., LTD.	WH-D1-01
	HAISEN TECHNIK CO., LTD. / COSCO SHIPPING Heavy Industry Technology (Weihai) Co., Ltd.	WH-S2-01

EMC in the range 2 GHz to 6 GHz according to DNV-CG-0339 dated August 2021, shall be documented for the electric/electronic components, for installation on ships contracted for construction on or after 2022-01-01.

Hazardous area / Ex-proof

The filter motor and differential pressure transmitter on Filter unit, the long/short covers and pressure/temperature/light intensity transmitter on UV Reactor, Control System Box, Control System Junction Box, Filter Control Box, flowmeters, butterfly valve drivers and drain pump of the BLUE OCEAN SHIELD BWMS have Ex-certificates for installation in hazardous area zone 1, gas group IIB and temperature class T4. The installations are to be approved case by case.

The BLUE OCEAN SHIELD BWMS models suitable for installation in hazardous area are designated with the suffix “-Ex” to normal models, i.e. BOS100(Ex) to BOS3200(Ex).

Ex-certification is not covered by this type approval certificate. Installation in hazardous area is to be approved in each case according to the DNV Rules and Ex-Certification/Special Condition for Safe Use listed in valid Ex-certificates issued by a notified/recognized Certification Body.

Documents approval

The following documentation is to be submitted for approval for each BWMS installation:

- Piping and Instrumentation Diagram (P&ID) of the ballast system including the treatment system installation
- Power supply arrangement
- Interface description towards ship’s existing systems including alarms for failure
- Description confirming the arrangement of alarms for bypass of the BWMS system (as part of Ballast Water Management Plan)
- List of Ex-equipment according to DNV Rules Pt.4 Ch.8 Sec.11, if the system is to be installed in hazardous area
- Generic Commissioning Test Plan, CHIT, Rev.7, 2022.06.15

Type Approval documentation

Biological test reports

- Land-based operational performance and biological efficacy test of BLUE OCEAN SHIELD (BOS) BWMS, SHOU-BWDL, V1.2, 2022.04.15
- Biological efficacy performance evaluation of BLUE OCEAN SHIELD 300 BWMS in land-based test (Denmark), DHI Denmark, Rev. Final, 2019.03.15
- Biological efficacy performance evaluation of BLUE OCEAN SHIELD 300 BWMS in land-based test (Singapore), DHI Singapore, Rev. Revised Final, 2019.06.11
- Biological efficacy performance evaluation of BOS BWMS in shipboard test, DHI Denmark, Rev. Final, 2019.03.14
- Centre of Marine Environmental Measurements (CMEM), 2015A. Test report. Report Number: SZ-201512001.

- Centre of Marine Environmental Measurements (CMEM), 2015B. Test report. Report Number: C0430.
- Centre of Marine Environmental Measurements (CMEM), 2017. Test report. Report Number: C0409.

Environmental test reports

- Test report for Type Approval of Ex-BOS BWMS S649A-2019G1, Shanghai Marine Auxiliary Mechanical & Electric Equipment Performance Environmental Test Centre, Rev. Signed, 2020.06.05
- Test report for Type Approval of BOS BWMS S502A-2018, Shanghai Marine Auxiliary Mechanical & Electric Equipment Performance Environmental Test Centre, Rev. Signed, 2019.04.09

Other reports

- Test report for EMC test of BOS BWMS S897A-DC-2021, Shanghai Marine Auxiliary Mechanical & Electric Equipment Performance Environmental Test Centre, Rev. Signed, 2022.01.05
- Test report for UV Lamp S805A-ZD-2020, Shanghai Marine Auxiliary Mechanical & Electric Equipment Performance Environmental Test Centre, Rev. Signed, 2021.01.28
- Test report for UV Power Control Cupboard and Differential Pressure Transmitter S462A-2019G, Shanghai Marine Auxiliary Mechanical & Electric Equipment Performance Environmental Test Centre, Rev. Signed, 2020.12.07
- Renewal/Periodical Type Approval Assessment Report, DNV GL, 2020.11.18
- Initial Type Approval Assessment Report, DNV GL, 2019.05.15
- Evaluation of regrowth for type approval of the BLUE OCEAN SHIELD BWMS, DNV GL, 2019.03.05
- Full-Scale Test to Support CFD Validation Study of BLUE OCEAN SHIELD 300 Ballast Water Management System, DHI Denmark, Rev. Final, 2018.11.28

System documents

- BLUE OCEAN SHIELD (BOS) Ballast Water Management System Operation Maintenance Safety Manual (OMSM) with Appendixes, CHIT, Rev.3, 2022.04.28
- Ex-proof BLUE OCEAN SHIELD (BOS) Ballast Water Management System Operation Maintenance Safety Manual (OMSM Ex) with Appendixes, CHIT, Rev.3, 2022.04.28
- ISO 9001-2015 Management System Certificate by DNV, 124861-2012-AQ-RGC-RvA, 2021.10.31-2024.10.31

Tests carried out

- Land-based testing using BOS300 model with FH300 filter at SHOU-BWDL for system modifications in accordance with Resolution MEPC.300(72) and USCG 46 CFR 162.060-26
- Land-based testing using BOS300 model with FH300 filter at DHI Singapore in accordance with Resolution MEPC.279(70) and USCG 46 CFR 162.060-26
- Land-based testing using BOS300 model with FH300 filter at DHI Denmark in accordance with Resolution MEPC.279(70) and USCG 46 CFR 162.060-26
- Shipboard testing using BOS1200 model with FH1200 filter in accordance with Resolution MEPC.279(70) and USCG 46 CFR 162.060-26
- Environmental testing in accordance with DNVGL-CG-0339 Class Guideline, IMO Resolution MEPC.279(70), USCG 46 CFR 162.060-30 and IACS UR E10
- Environmental testing of BOS BWMS Ex-proof models in accordance with DNVGL-CG-0339 Class Guideline, IMO Resolution MEPC.300(72), USCG 46 CFR 162.060-30 and IACS UR E10
- Function test of the explosion-proof pressurized cabinet of Ex-BOS BWMS, 2020.11.06
- Function tests of the control and automation system witnessed by DNV GL
- Additional tests for validation of CFD model
- Additional tests for verification of regrowth effect

Marking of product

For Traceability of this Type Approval, each treatment system is to be marked with:

- Manufacturer's name or trademark
- Type designation
- Serial number

Periodical assessment

For retention of the Type Approval, DNV GL Surveyor shall perform periodical assessments to verify that the conditions of the TA are not altered since the certificate was issued. The scope of periodical assessment includes:

- Review of the TA documentation and verification that the documentation is still used as basis for the production
- Review of possible changes in design, material and performance of the product.
- Verification of the company’s production and quality systems ensuring continued consistent production of the type approved products to the required quality.
- Verification that the product marking for identification and traceability to the TA Certificate is not altered.

Copy of type approval certificate

A copy of this Type Approval Certificate shall be carried on board a ship fitted with this ballast water management system, for inspection on board the ship. A reference to the test protocol and a copy of the test results should be available for inspection onboard the vessel.

Revision history

Rev.	Date of issuance	Description
-	2019-07-05	Type approval certificate in compliance with Resolution MEPC.279(70)
1	2020-12-02	Changed to compliance with Resolution MEPC.300(72); Inclusion of Ex-proof models of the BOS BWMS, FH1650 filter model, and alternate instruments/components; Inclusion of Revision history
2	2022-06-13	System upgrades including holding time, de-ballast operation, freshwater operation mode, UV lamp power and US cleaning operation; Change of company name

ANNEX 1 SUMMARY OF TESTING

Summary of land-based testing for WECOSCO BLUE OCEAN SHIELD (BOS) BWMS

Table 1 Test water conditions and operational data in land-based testing of the WECOSCO BLUE OCEAN SHIELD (BOS) BWMS with BOS300 model with TRC 300 m³/h in 2017-2019 at the DHI test facility in Singapore and Denmark. All data are inlet samples.

Test cycle	Salinity (PSU)	Temp. (°C)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVT (%)	Average UVI (mW/cm ²)	Average UVF (%)	Average flowrate (m ³ /h)		Holding time (hours)
									Before filter	After filter	
COSBW01	19.5	28.3	9.0	7.4	57.9	74.6	139	72	339.8	285.0	32
COSBW02	18.7	30.7	7.9	6.0	64.0	75.0	476	74	342.8	289.9	48
COSBW03	18.4	30.0	6.8	6.3	65.6	74.1	478	74	339.7	287.9	48
COSBW04	18.4	30.3	7.8	7.9	61.6	74.4	447	71	340.2	289.0	48
COSBW05	18.3	27.0	9.5	10.0	70.4	63.5	277	58	198.4	148.5	48
COSBW06	18.4	29.6	8.7	8.1	63.8	55.9	250	55	196.9	146.5	48
COSBW07	19.2	30.5	8.7	8.2	74.2	55.2	238	53	192.4	145.1	48
COSBW08	18.9	30.5	10.4	9.0	67.2	54.6	237	53	195.8	149.3	48
COSBW09	19.0	31.1	9.2	9.7	68.2	54.6	240	54	204.8	148.3	48
COSBW10	19.0	29.7	10.0	10.3	68.1	53.9	220	51	206.4	148.2	48
COSMW01	32.7	30.7	8.6	7.8	42.7	56.5	108	35	193.8	147.1	48
COSMW02	34.7	29.8	7.7	6.2	31.4	76.6	485	76	328.9	284.6	48
COSMW03	32.2	30.1	9.2	6.6	39.3	74.8	463	74	348.4	290.6	48
COSMW04	29.2	30.3	9.6	5.9	35.0	87.8	480	86	333.1	277.4	-
COSMW05	31.0	29.4	8.5	6.9	45.5	86.2	449	84	349.4	290.2	48
COSMW06	30.8	29.5	9.7	7.5	38.4	57.1	238	53	209.7	149.6	48
COSMW07	32.0	28.9	9.2	7.1	37.3	57.6	234	53	210.0	148.5	48
COSFW01	0.1	30.1	8.8	6.0	69.5	64.4	452	74	289.7	243.4	48
COSFW02	0.9	27.7	-	-	-	85.1	581	83	238.5	196.2	-
COSFW03	0.1	29.2	8.4	7.0	49.3	85.9	520	93	345.4	287.0	48
COSFW04	0.1	29.3	9.2	6.1	34.7	81.2	627	89	334.5	271.4	-
F-1 ⁽¹⁾	0.34	19	7.3	5.2	52	50	262	51	182	124	72
F-2 ⁽¹⁾	0.39	20	6.5	6.9	60	55	382	55	184	127	72
F-3 ⁽¹⁾	0.41	18	6.8	6.4	56	57	453	66	212	158	120
F-4 ⁽¹⁾	0.38	20	7.7	6.7	59	54	384	56	191	123	120
F-5 ⁽¹⁾	0.40	21	8.3	5.9	66	51	377	55	184	124	72
B-1 ⁽¹⁾⁽²⁾	17	21	7.6	7.9	69	65	- ⁽³⁾	- ⁽³⁾	220	157	120
B-2 ⁽¹⁾⁽²⁾	17	21	7.6	7.9	69	65	- ⁽³⁾	- ⁽³⁾	212	147	120

(1) These test cycles were carried out at DHI Denmark

- (2) Test cycles B-1 and B-2 were run consecutively by use of the same test water without control. These two test cycles were performed for evaluation of re-growth as stated in Section 2.6 of IMO Resolution MEPC. 279(70)
- (3) UV-I and UVF were not recorded due to malfunction of the UV-I sensor on the BWMS

Table 2 Average densities of live organisms in inlet and treated discharge water during land-based testing of the WECOSCO BLUE OCEAN SHIELD (BOS) BWMS BOS300 model. Live organisms ≥ 10 and $< 50 \mu\text{m}$ were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli*, *Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test #	Organism densities in inlet water		$\geq 50 \mu\text{m}$ organisms' densities in discharge water (organisms/m ³)		≥ 10 and $< 50 \mu\text{m}$ organisms' densities in discharge water (organisms/mL)	
	$\geq 50 \mu\text{m}$ (org/m ³)	≥ 10 - $< 50 \mu\text{m}$ (org/mL)	Treated	Control	Treated	Control
COSBW01 ⁽¹⁾	228,889	1,422	3	107,709	68	917
COSBW02	154,417	6,867	0	14,532	1	129
COSBW03 ⁽²⁾	733,088	1,673	0	66	1	32
COSBW04	414,000	1,693	0	77,163	6	271
COSBW05	415,022	986	0	147,234	6	156
COSBW06	532,311	2,267	0	117,745	2	985
COSBW07 ⁽²⁾	543,721	1,316	0	121,752	4	54
COSBW08 ⁽²⁾	520,140	2,322	0	236,889	6	43
COSBW09 ⁽³⁾	155,734	1,749	0	40,127	17	345
COSBW10	400,018	1,432	0	173,267	2	799
COSMW01 ⁽¹⁾	556,222	2,869	0	167,967	21	330
COSMW02	232,800	2,107	0	113,902	2	669
COSMW03	370,906	1,665	0	72,507	1	323
COSMW04 ⁽⁴⁾	323,282	905	-	-	-	-
COSMW05	452,082	1,709	0	209,615	4	347
COSMW06	223,747	1,389	0	147,658	6	950
COSMW07	205,733	1,229	0	126,844	5	484
COSFW01 ⁽¹⁾	128,350	1,994	0	6,246	76	363
COSFW02 ⁽⁴⁾	-	-	-	-	-	-
COSFW03	255,127	1,352	0	183,636	9	372
COSFW04 ⁽⁴⁾	92,105	1,555	-	-	-	-

Test #	Organism densities in inlet water		≥50 µm organisms' densities in discharge water (organisms/m ³)		≥10 and <50 µm organisms' densities in discharge water (organisms/mL)	
	≥50 µm (org/m ³)	≥10-<50 µm (org/mL)	Treated	Control	Treated	Control
F-1	297,361	1,152	0	95,972	0.33	1,270
F-2	308,433	1,485	0	137,524	1.7	1,267
F-3	468,811	1,302	0	136,978	1.8	1,504
F-4	763,972	1,297	0	254,527	0.50	692
F-5	476,695	1,477	0	316,413	1.7	776
B-1	445,100	2,545	0	-	0	-
B-2	509,533	2,316	0	-	0.17	-

- (1) These test cycles failed because the density of 10–50 µm exceeded the discharge standard
- (2) These test cycles are defined invalid due to insufficient organisms in the ≥10–<50 µm size class in the control discharge water
- (3) COSBW09 is defined invalid due to the abnormally low UV-I/UV-F during de-ballast, which is outside the performance claim for the BWMS
- (4) COSMW04 was cancelled as DHI could not meet the minimum requirements for organisms in the ≥10–<50 µm size class in the inlet water; COSFW02 and COSFW04 were not completed due to filter clogging issues during ballasting

Table 3 Test water conditions and operational data in additional land-based testing of the CHIT BLUE OCEAN SHIELD (BOS) BWMS with BOS300 model with TRC 300 m³/h in 2021 at SHOU-BWDL in China. All data are inlet samples.

Test cycle	Salinity (PSU)	Temp. (°C)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVT (%)	Average UVF (%)	Average UVI (mW/cm ²)	Average flowrate after filter (m ³ /h)	Holding time (hours)
BW01	17.2	29.2	6.5	5.5	60.3	71.5	80.6	445.0	307	2
BW02	18.7	28.6	6.7	5.8	53.3	63.0	66.1	380.3	206	2
BW03 ⁽¹⁾⁽²⁾	18.2	28.0	6.6	5.8	62.2	51.7	56.7	297.3	154	120
BW04	16.5	25.3	7.7	5.7	57.6	70.8	80.8	511.4	289	2
BW05 ⁽¹⁾⁽²⁾	18.8	25.8	8.8	5.8	60.7	52.8	58.9	330.6	154	120
MW01	29.7	27.4	7.6	5.4	55.3	68.8	67.4	407.2	255	2
MW02	29.2	27.1	8.6	5.6	44.1	57.5	62.6	341.0	151	2
MW03	29.2	26.7	7.7	5.3	48.7	58.6	55.5	279.6	147	2
MW04 ⁽¹⁾⁽²⁾	29.1	26.5	7.6	5.3	39.6	74.3	71.2	411.2	282	120
MW05 ⁽¹⁾⁽²⁾	29.2	27.2	7.7	5.3	41.8	71.6	72.6	423.4	306	120
FW01	0.5	19.8	7.8	5.2	52.5	50.4	61.5	371.9	147	2
FW02	0.4	20.2	7.8	5.3	56.7	49.1	58.8	367.0	149	2
FW03	0.4	20.4	7.4	5.3	56.3	51.6	59.0	383.9	153	2
FW04 ⁽¹⁾⁽²⁾	0.4	20.3	7.6	5.3	52.1	52.0	59.5	398.3	152	120
FW05 ⁽¹⁾⁽²⁾	0.4	17.3	7.6	5.2	53.1	53.7	59.4	399.1	152	120

(1) These test cycles were performed for evaluation of re-growth as stated in IMO Resolution MEPC.300(72)

(2) Additional sampling and analysis for ≥50 µm organisms before the second treatment (UV)

Table 4 Average densities of live organisms in inlet and treated discharge water during additional land-based testing of the CHIT BLUE OCEAN SHIELD (BOS) BWMS BOS300 model. Live organisms ≥10 and <50 µm were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli*, *Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test #	Organism densities in inlet water		Discharge before 2 nd UV treatment	≥50 µm organisms' densities in discharge water (organisms/m ³)		≥10 and <50 µm organisms' densities in discharge water (organisms/mL)	
	≥50 µm (org/m ³)	≥10-<50 µm (org/mL)	≥50 µm (org/m ³)	Treated	Control	Treated	Control
BW01	120,000	1,275	/	2.0	71,350	4.2	1,110
BW02	122,407	1,291	/	2.0	71,493	6.5	1,080
BW03 ⁽¹⁾⁽²⁾	120,370	1,294	2.0	0	171,833	3.5	338
BW04	124,907	1,299	/	5.7	96,853	4.2	1,051
BW05 ⁽¹⁾⁽²⁾	125,278	1,285	3.0	0	105,600	6.0	329

Test #	Organism densities in inlet water		Discharge before 2 nd UV treatment	≥50 µm organisms' densities in discharge water (organisms/m ³)		≥10 and <50 µm organisms' densities in discharge water (organisms/mL)	
	≥50 µm (org/m ³)	≥10-<50 µm (org/mL)	≥50 µm (org/m ³)	Treated	Control	Treated	Control
MW01	120,370	1,282	/	2.3	83,930	6.2	1,070
MW02	118,889	1,306	/	0.7	95,893	4.3	1,079
MW03	129,907	1,284	/	0.7	92,043	4.3	1,042
MW04 ⁽¹⁾⁽²⁾	131,667	1,302	1.0	0	102,363	5.7	378
MW05 ⁽¹⁾⁽²⁾	139,167	1,278	3.0	1.0	107,473	2.5	338
FW01	205,333	1,516	/	6.3	171,150	1.2	1,218
FW02	180,222	1,504	/	5.3	164,250	1.0	1,241
FW03	183,889	1,587	/	5.3	158,767	1.5	1,299
FW04 ⁽¹⁾⁽²⁾	170,952	1,384	2.0	0	145,483	0.3	536
FW05 ⁽¹⁾⁽²⁾	182,222	1,145	1.0	0	145,350	1.2	521

(1) These test cycles were performed for evaluation of re-growth as stated in IMO Resolution MEPC.300(72)
 (2) Additional sampling and analysis for ≥50 µm organisms before the second treatment (UV)

Summary of shipboard testing for WECOSCO BLUE OCEAN SHIELD (BOS) BWMS

Table 5 Test water conditions, operational data, and organism density counts in shipboard testing of the WECOSCO BLUE OCEAN SHIELD (BOS) BWMS BOS1200 model with TRC 1200 m³/h, January-August 2018 on board vessel YU XIAO FENG. Live organisms ≥10 and <50 μm were quantified by microscopy counting after staining with CMFDA/FDA. All counts of pathogenic bacteria (*E. coli*, *Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test #	Salinity (PSU)	Temp (°C)	Average flowrate during ballast (m ³ /h)	Holding time (hour:min)	UVT (%)	UVF (%)	UV-I (mW/cm ²)	Organisms ≥50 μm (org/m ³)		Organisms ≥10-<50 μm (org/mL)	
								Inlet	Discharge	Inlet	Discharge
1	29	16	1,191	25:42	91	100	1,009	16,746	0	415	2.3
2	28	14	1,007	33:35	88	100	911	16,859	0	128	1.0
3	31	12	940	123:27	79	88	740	24,572	0	356	0
4	31	11	1,184	69:48	60	79	681	28,721	0	162	0.83
5	34	26	941	84:41	90	100	852	98,888	0	229	2.5