Certificate No:
TAP00002H4

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Ballast Water Management System

with type designation(s)
CompactClean BWMS

Issued to
DESMI Ocean Guard A/S
Nørresundby, **Denmark**

is found to comply with
IMO Resolution MEPC.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)
DNV class programme DNV-CP-0209 – Type approval – Ballast water management systems
DNV rules for classification – Ships

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 the BWMS Code (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 certificate.

For the compliance with the BWMS Code, the certificate is issued on behalf of Transport Canada, Marine Safety & Security.

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 **2022-03-01**

This Certificate is valid until **2026-07-18**.
DNV local station: **Denmark CMC**

Approval Engineer: **Michael Lehmann**

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.

Name of ballast water management system (BWMS)

CompactClean BWMS

Ballast water management system manufactured by

DESMI Ocean Guard A/S

Place of production

DESMI Pumping Technology A/S
Tagholm 1
9400 Nørresundby
Denmark

DESMI Pumping Technology (Suzhou) Co., Ltd.
108 Houdai Street, Suzhou Industrial Park
Suzhou, 215121
Jiangsu Province
P.R. China

Type and model designations

The CompactClean BWMS has the model designation VxxxxxFyyyy**N**S00 for models suitable for non-hazardous areas and VxxxxxFyyyy**E**S00 for models suitable for installation in hazardous areas, where

Vxxxxx is the applicable UV unit model (refer to page 4 of this certificate);

Fyyyy is the applicable Filtrex filter model or Byyyy is the applicable BOLLFILTER filter model (refer to page 4 of this certificate);

S is the skid mounted delivery type, L is the loose component delivery type, D is the deckhouse delivery type and M is the low version of the skid mounted delivery type;

00 is the standard type while B0 or BC is used for BWMS installations with a booster pump and 0C or BC is used for a custom made type (in terms of selected pipe materials).

The CompactClean BWMS is available in two versions:

1) CompactClean (CC): The BWMS can only be operated in US mode.
2) CompactClean OptIMO (OptIMO): The BWMS may be operated either in IMO or US mode.

Equipment / Assembly drawings

The CompactClean BWMS shall be installed in accordance with the documents listed below.

Type	Title		Drawing No.	Revision
Operation, maintenance and safety manual (OMSM)	CompactClean DESMI Ocean Guard BWMS Operation Maintenance and Safety Manual		161335	E
Piping and instrumentation diagrams (P&ID)	Generic P&ID		470300	A
List of electrical/electronic components	Component Overview	*Non-EX*	162240	B
		EX	161576	B
General arrangement (GA) drawings	Arrangement drawing	*Non-EX*	VxxxxxFyyyyNS00 (1)	A
		EX	VxxxxxFyyyyES00 (1)	A
Electrical diagrams	Cable plan	*Non-EX*	470540	C2
		EX	470541	C1

(1) Refer to the above description of the CompactClean BWMS model designation and the tables on page 4 for the UV unit models and filter models.

Other equipment manufactured by

The CompactClean BWMS applies either filters of the ACB series (20 µm woven mesh) manufactured by Filtrex or filters of the aquaBoll BWT BB series (25 µm woven mesh) manufactured by Boll & Kirch Filterbau (BOLLFILTER).

Treatment Rated Capacity

35 – 2500 m^3/h

Product description

Treatment sequence:

- Ballast water uptake: Filtration followed by UV treatment
- Ballast water discharge: UV treatment

System design limitations / Water quality parameters

Temperature & salinity

Neither temperature nor salinity of the ballast water is a limiting condition for the CompactClean BWMS.

System design limitations / Operational parameters

Holding time

The CompactClean BWMS, when operated in the IMO or US mode, has demonstrated performance to the discharge standard with a minimum holding time between uptake and discharge of 24 hours in land-based testing in each of the three salinity ranges. UV treatment is instant and does not require any hold time in a ballast tank to render organisms non-viable. Therefore, holding time is not found to be a limiting condition for the BWMS.

UV dose

The CompactClean BWMS monitors UV intensity (UVI) and automatically dims the UV lamp power (maximum dimming is 20% of maximum rated lamp power) when UVI exceeds a defined UVI limit in order to maintain a constant UVI at that limit.

At lower UVT levels, the CompactClean BWMS automatically adjusts the flow rate with the flow control valve W1-RM2. Optionally, the ballast water flow rate may also by controlled through an additional variable frequency drive installed on the ballast water pump.

The CompactClean BWMS has two compliance modes: IMO mode and US mode. The UVI limits for dimming of the UV lamp power, the UVI limits for operating at TRC of the UV unit and the lowest UVI for which the BWMS is type approved are stated below for these two compliance modes. The same UVI limits apply to all UV unit models.

The CompactClean OptIMO BWMS may be operated in either the IMO mode or the US mode.

Compliance mode	UVI limit for dimming of the UV lamp power [W/m^2]	UVI limit for operating at TRC of UV unit (1) [W/m^2]	Lowest UVI limit for which BWMS is type approved (2) [W/m^2]
IMO mode	900	800	170
US mode	1000	880	227

(1) As per the CFD analyses provided, this UVI limit corresponds to an UVT of 62% (IMO mode) or 65% (US mode).
(2) The lowest UVT at which land-based tests confirmed treatment in compliance with the discharge standard was 35% (IMO mode) or 40% (US mode).

Treatment Rated Capacity

For ballast water uptake, the Treatment Rated Capacity (TRC) of a specific CompactClean BWMS model is limited by the maximum flow rate of either the selected UV unit model or the selected filter model, whichever is lower. The TRC for ballast water discharge is limited by the maximum flow rate of the selected UV unit model.

The treatment flow rate is monitored by a flowmeter at the BWMS inlet (before filter).

The maximum flow rate of the different UV unit models, Filtrex ACB filter models and BOLLFILTER aquaBoll BWT BB filter models are stated below.

UV unit model	Maximum flow rate [m^3/h]	
	IMO mode	US mode
V10024	60	40
V15044	135	85
V15064	240	160
V20066	370	250
V20086	510	340
V25126	750	500
V30186	1 200	870
V35246	1 650	1 180
V40366	2 500	1 740

Filter model	Filtrex filter model	Maximum flow rate [m^3/h]
F0035	ACB-903-65	35
F0055	ACB-904-80	55
F0087	ACB-906-100	87
F0135	ACB-910-150	135
F0190	ACB-915-150	190
F0255	ACB-935-200	255
F0340	ACB-945-200	340
F0515	ACB-955-250	515
F0770	ACB-985-300	770
F1040	ACB-999-350	1040
F1500	ACB-9100-400	1500
F2100	ACB-9120-500	2100
F3000	ACB-9200-600	3000

Filter model	BOLLFILTER filter model	Maximum flow rate [m^3/h]
B0050	aquaBoll BWT BB 240x230 DN80	50
B0100	aquaBoll BWT BB 330x300 DN100	100
B0170	aquaBoll BWT BB 400x410 DN150	170
B0340	aquaBoll BWT BB 430X730 DN200	340
B0515	aquaBoll BWT BB 540x840 DN250	515
B0770	aquaBoll BWT BB 580x1150 DN300	770
B1040	aquaBoll BWT BB 700x1250 DN350	1040
B1500	aquaBoll BWT BB 800X1535 DN400	1500
B2000	aquaBoll BWT BB 1000x1535 DN500	2000
B2500	aquaBoll BWT BB 1200x1535 DN600	2500
B3000	aquaBoll BWT BB 1400x1535 DN600	3000

Pressure

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

Minimum pressure at filter inlet	Maximum operating pressure	Filter differential pressure triggering backflushing	Maximum filter differential pressure
1.3 bar (2 bar recommended)	10 bar	0.3 bar	1.1 bar

Control and monitoring equipment

Software version

The CompactClean BWMS is type approved with the system control software version 1.XX.YYYY. In the software version the “1” represents the final version number of the software. The final version of the software is the approved major version. The final version is incremented by one in case of any change to the control and operating philosophy of the CompactClean BWMS. The “YYYY” represents the build version and is incremented by one for minor changes such as bugfixes. When build versions are approved, the release version is incremented by one.

Any changes to the software are to be recorded as long as the system is in use on board. Records of any software changes resulting in a revision of the final version number or any changes to the hardware are to be forwarded to DNV for evaluation. Testing of the application functions of the revised software may be required.

Safety measures

The CompactClean BWMS is type approved with the following instruments for monitoring the safe operation of the BWMS and for activating, as necessary, an automatic shutdown of the BWMS:

- Pressure transmitters W1-H1-BP1 and W1-H1-BP2
- UV unit temperature sensor W1-V1-BT1
- Flowmeter W1-BF1
- UV unit level switch W1-BL1

For installation on vessels classed by DNV, the UV unit temperature sensor W1-V1-BT1 shall be arranged with safety function independent of the BWMS control.

Electrical and electronic components

The CompactClean BWMS is type approved with the electrical and electronic components indicated on the P&ID and specified on the list of electrical/electronic components. Except for the components listed below, alternate models to the ones specified on the list of electrical/electronic components 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 (rev. 7 or as amended).

For the following electrical and electronic components, only the models specified below shall be used:

Tag No.	Component name	Manufacturer	Model(s)
UC01	Main panel	DESMI Ocean Guard	-
UC03	External control box	DESMI Ocean Guard	-
W1-V1-EA	UV lamps	DESMI Ocean Guard	4 kW, 6 kW
W1-V1-BR1	UV sensor	IL Metronic Sensortechnik	SUV 20.2

Hazardous area / Ex-proof

The EX models of the CompactClean BWMS, with the exception of the main panel and the variable frequency drive, have been found to be in compliance with DNV rules for classification of ships Pt.4 Ch.8 Sec.11 and are suitable for use in hazardous area Zone 1. The main panel and variable frequency drive must be located in non-hazardous areas.

The applicable IECEx classifications are IECEx EX II 2G Ex IIB T4 Gb, IECEx EX II 2G Ex IIC T4 Gb and IECEx EX II 2G Ex IIB + H2 T4 Gb.

Installations in a hazardous area are to be approved in each case according to the rules and Ex-certification / special condition for safe use listed in a valid Ex-certificate issued by a notified/recognized Certification Body. Ex-certification is not covered by this certificate.

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
- QC SAT Test Report for CompactClean
- Interface description towards ship's existing systems including alarms for failure

Type approval documentation

Test plan and reports:

- DHI: Biological efficacy performance evaluation of CompactClean Ballast Water Management System in land-based test - Land-based test report (Project No. 11821290,Final report version 2, 2018-09-20)
- DHI: Biological efficacy performance evaluation of CompactClean Ballast Water Management System in shipboard test – Shipboard test report (Project No. 11821290, Final report version 2, 2018-09-21)
- DHI: Biological efficacy performance evaluation of CompactClean Ballast Water Management System in land-based test - Land-based test report (Project No. 11824997,Final report, 2020-12-07)
- DHI: Biological efficacy performance evaluation of CompactClean Ballast Water Management System in land-based test (Project No. 11825920, Final report, 2021-07-02)
- DHI: Biological efficacy performance evaluation of CompactClean Ballast Water Management System in land-based test - Additional test cycles with Bollfilter (Project No. 11825920, Final report, 2021-10-08)
- FORCE Technology: Test report – Marine type testing of DESMI CompactClean BWMS (Report No. 117-36341-1, revision 1)
- FORCE Technology: Test report – Supplementary tests of CompactClean BWMS (Report No. 121-28825-1, initial revision)

System documentation:

- DESMI Ocean Guard: CompactClean BWMS Operation Maintenance and Safety Manual (Document ID 161335, rev E)
- DESMI Ocean Guard: Design Study Filtrex Filter vs. Boll Filter (V.A. 16.07.2021)
- DESMI Ocean Guard: Hold Time Limitation of CompactClean BWMS (Version 1)
- DESMI Ocean Guard: QC SAT Test Report for CompactClean (QC SAT LCD NEX, rev A)
- DESMI Ocean Guard: QC SAT Test Report for CompactClean (QC SAT LCD IEX, rev A)
- DESMI Ocean Guard: Instruction - Control of circuit diagrams, control programs and set parameters for BWMS controls (Document ID 158338, version 7)
- DESMI Ocean Guard: FMEA - Two layers of safety to protect the system against overheating due to UV-lamp operating without control system
- R & R Consult: Scaling of CompactClean UV disinfection unit (Desmi-180530- USCG report)
- R & R Consult: CompactClean IMO-scaling (DESMI-210609-CompactClean IMO-scaling)
- R & R Consult: CompactClean USCG rescaling (DESMI-210609-CompactClean USCG-rescaling)
- DNV: Evaluation test report - Equivalence of the aquaBoll BWT, BWT RB and 6.18.3 filter designs (Report No.: 262.1-034941-J-3, Rev. 0)

Tests carried out

- Land-based testing from September 2017 to April 2018 with a CompactClean BWMS with a TRC of 340 m^3/h operated in US mode and equipped with a UV unit V20086 and a Filtrex ACB-945-200 filter
- Shipboard testing from November 2017 to June 2018 with a CompactClean BWMS with a TRC of 1000 m^3/h operated in US mode and equipped with a UV unit V35246 and a Filtrex ACB-999-350 filer
- Additional land-based testing from July to September 2020 with a CompactClean BWMS with a TRC of 340 m^3/h operated in US mode and equipped with a UV unit V20086 and a BOLLFILTER aquaBoll BWT DN200 filter
- Additional land-based testing from February to June 2021 with a CompactClean BWMS with a TRC of 510 m^3/h operated in IMO mode and equipped with a UV unit V20086 and a Filtrex ACB-955-250 filter
- Additional land-based testing from July to August 2021 with a CompactClean BWMS with a TRC of 510 m^3/h operated in IMO mode and equipped with a UV unit V20086 and a BOLLFILTER aquaBoll BWT BB DN250 filter
- Environmental testing in accordance with DNV class guidelines for Environmental test specification for electrical, electronic and programmable equipment and systems (DNVGL-CG-0339, December 2019) and IACS UR E10 (rev. 8)

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 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 should always be carried on board a vessel fitted with this ballast water management system. An annex containing the summary reports of the test results of land-based and shipboard tests should be available for inspection on board the vessel.

Revision history of this certificate

Revision No.	Date of Issuance	Description
-	2022-03-01	The CompactClean BWMS was initially type approved in accordance with the IMO BWMS Code (Resolution MEPC.300(72)) on 2018-09-21 by Lloyd's Register EMEA (Certificate No. CPN1700108) on behalf of the Danish Environmental Protection Agency (DEPA) and Danish Maritime Authority (DMA). The Danish authorities informed IMO of this type approval in document MEPC 74/INF.32. The BWMS was later upgraded to introduce a new IMO mode of operation with an alternate UV dose control curve. Moreover, three new scaled UV unit models were added and filters of the aquaBoll BWT BB filter series manufactured by BOLLFILTER were added as an alternative to the filters of the ABC filter series manufactured by Filtrex. The upgraded BWMS was on 2021-07-19 type approved by DNV (Certificate No. TAP00002DR) on behalf of the Danish authorities. The Danish authorities informed IMO of this type approval in document MEPC 77/INF.12. The type approval was subsequently amended on 2021-10-13 and 2022-02-08. This initial type approval on behalf of Transport Canada, Marine Safety & Security, is based on the DNV type approval certificate No. TAP00002DR (Revision No. 2).

ANNEX: SUMMARY OF TESTING

Land-based testing

Table 1 Test water conditions and operational parameters in land-based testing at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, from September 2017 to April 2018 with a CompactClean BWMS with a TRC of 340 m³/h operated in US mode and equipped with a UV unit V20086 and a Filtrex ACB-945-200 filter

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [days]	Average UVI at ballasting [W/m²]	Average flow rate before filtration [m³/h]
F-3	13	0.37	54	6.7	5.4	59	5	552 ± 6	193
F-4	13	0.37	54	6.7	5.4	59	5	549 ± 5	192
F-5	8.9	0.36	47	11	6.2	59	1	318 ± 3	99
F-6	9	0.36	47	11	6.2	59	1	317 ± 2	98
F-7	6.9	0.36	45	11	5.9	51	5	280 ± 3	82
B-1	15	18	42	18	9.4	60	1	245 ± 3	104
B-2	12	19	56	13	7.2	58	5	498 ± 2	174
B-3	12	19	56	13	7.2	58	5	498 ± 2	174
B-4	4.9	19	65	7.6	7.1	54	1	876 ± 5	330
B-5	5	19	65	7.6	7.1	54	1	877 ± 19	328
M-1	6.3	29	68	7.3	6.2	61	1	926 ± 13	332
M-2	6.3	29	68	7.3	6.2	61	1	922 ± 21	332
M-3	1.2	28	62	7.6	10	81	5	889 ± 16	329
M-4	1.3	28	62	7.6	10	81	5	888 ± 21	329
M-5	2.5	28	71	7	8	58	6	1 025 ± 12	332

Table 2 Average numbers of live organisms in inlet and treated discharge water during land-based testing from September 2017 to April 2018. 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.

	Organism densities in influent water		Organism densities in discharge water			
	Organisms ≥50 µm [organisms/m³]	Organisms ≥10-<50 µm [organisms/mL]	Organisms ≥50 µm [organisms/m³]		Organisms ≥10-<50 µm [organisms/mL]	
Test cycle			Treated	Control	Treated	Control
F-3	502 350	1 108	0	258 169 (1)	0.83	1 159 (1)
F-4	523 742	1 179	0		1.3	
F-5	468 556	3 456	4.6	208 074 (1)	7	2 014 (1)
F-6	311 073	3 091	0.57		8	
F-7	346 614	2 936	0	177 753	5.0	1 850
B-1	244 114	1 373	1.0	96 060	9.3	890
B-2	188 653	1 094	0	62 781 (1)	3.5	1 941 (1)
B-3	232 694	1 183	0.33		4.8	
B-4	251 153	1 424	0	50 519 (1)	6.5	790 (1)
B-5	191 233	1 073	0		5.0	
M-1	174 522	2 100	4.0	60 671 (1)	6.0	1 466 (1)
M-2	158 542	1 807	0		4.7	
M-3	229 531	6 839	0	135 936 (1)	0.17	771 (1)
M-4	221 678	7 750	0		0.83	
M-5	286 653	3 976	0	68 507	0	741

(1) Two test cycles were performed on the same day using the same control water tank.

Table 3 Test water conditions and operational parameters in additional land-based testing at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, from July to September 2020 with a CompactClean BWMS with a TRC of 340 m^3/h operated in US mode and equipped with a UV unit V20086 and a BOLLFILTER aquaBoll BWT DN200 filter

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [days]	Average UVI at ballasting [W/m^2]	Average flow rate before filtration [m^3/h]
F-2	21	0.42	49	8.6	9.5	64	1	417 ± 2	141
F-3	18	0.37	50	8.6	7.3	62	1	435 ± 2	151
F-5	16	0.42	41	13	6.1	60	1	244 ± 1	71
B-1	17	18	43	18	10	67	1	231 ± 5	69
B-2	19	18	60	11	8.5	67	1	582 ± 5	212
B-3	19	18	60	11	8.5	67	1	582 ± 4	211
M-1	18	28	62	10	7.9	63	1	649 ± 11	235
M-2	19	28	76	7.2	6.0	37	1	1 061 ± 7	332
M-3	19	28	76	7.2	6.0	37	1	1 037 ± 9	335

Table 4 Average numbers of live organisms in inlet and treated discharge water during additional land-based testing from July to September 2020. 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.

	Organism densities in influent water		Organism densities in discharge water			
	Organisms ≥50 µm [organisms/m^3]	Organisms ≥10-<50 µm [organisms/mL]	Organisms ≥50 µm [organisms/m^3]		Organisms ≥10-<50 µm [organisms/mL]	
Test cycle			Treated	Control	Treated	Control
F-2	384 167	1 222	0	166 194	0.83	867
F-3	539 911	1 778	0.52	224 049	3.8	1 376
F-5	199 944	1 589	0	92 333	2.3	1 614
B-1	347 194	1 221	1.7	218 283	0.33	807
B-2	149 392	1 195	0.33	83 495 (1)	2.2	1 886 (1)
B-3	177 631	1 213	1.7		1.7	
M-1	192 889	2 627	2.7	85 452	1.2	808
M-2	127 372	939 (2)	1.3	83 272 (1)	0.50	683 (1)
M-3	133 011	1 052	0		0.33	

(1) Two test cycles were performed on the same day using the same control water tank.
(2) The density of organisms in the size class ≥10-<50 µm in test cycle M-2 was below the requirements of MEPC.300(72). However, DNV evaluated and found that the density of organisms in the size class ≥10-<50 µm in the source water in this test cycle does not constitute a significant reduction in challenge conditions given that the deviations in challenge conditions were only 6%.

Table 5 Test water conditions and operational parameters in additional land-based testing at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, from February to June 2021 with a CompactClean BWMS with a TRC of 510 m^3/h operated in IMO mode and equipped with a UV unit V20086 and a Filtrex ACB-955-250 filter

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [days]	Average UVI at ballasting [W/m^2]	Average flow rate before filtration [m^3/h]
F-2	9.3	0.41	59	8.8	5.3	63	5	631± 5	401
F-3	9.5	0.41	59	8.8	5.3	63	5	626± 3	398
F-5	9	0.42	39	16	7.8	54	1	180± 0.6	95
F-6	12	0.44	42	15	7.3	64	1	221± 0.8	123
B-1	4.3	19	38	16	12	63	5	175± 3	89
B-4	4.1	20	55	12	5.7	71	1	441± 2	272
B-5	4.3	20	55	12	5.7	71	1	438± 2	269
B-6	5.4	19	43	16	9.4	71	5	224± 2	125
M-1	8.8	29	77	7.0	5.8	46	5	987± 3	513
M-2	8.9	29	77	7.0	5.8	46	5	987± 3	512
M-5	17	28	66	10	5.4	70	1	527± 2	330
M-6	17	28	66	10	5.4	70	1	526± 2	329

Table 6 Average numbers of live organisms in inlet and treated discharge water during additional land-based testing from February to June 2021. Live organisms ≥10 and <50 µm in the inlet water were quantified by microscopy counting after staining with CMFDA/FDA. Viable organisms ≥10 and <50 µm in discharge water were quantified by MPN Dilution Culture + Motility. All counts of pathogenic bacteria (*E. coli*, Enterococci and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

	Organism densities in influent water		Organism densities in discharge water			
	Organisms ≥50 µm	Organisms ≥10-<50 µm	Organisms ≥50 µm [organisms/m^3]		Organisms ≥10-<50 µm [organisms/mL]	
Test cycle	[organisms/m^3]	[organisms/mL]	Treated	Control	Treated	Control
F-2	90 889 (1)	2 144	0.33	75 310 (2)	3.0	>2 700 (2)
F-3	109 111	2 018	0		6.5	
F-5	148 211	2 143	0	101 338	1.1	>2 700
F-6	295 250	1 987	4.0	172 150	1.5	>2 700
B-1	276 217	2 453	0	33 441	<0.06	770
B-4	114 567	1 833	9.0	59 647 (2)	1.9	>2 700
B-5	176 850	1 869	4.7		3.2	
B-6	180 570	1 547	3.0	50 163	0.25	450
M-1	213 500	1 722	0	134 107 (2)	<0.06	440 (2)
M-2	201 583	1 504	0		<0.06	
M-5	230 111	1 720	0	134 132 (2)	0.12	920 (2)
M-6	267 167	1 436	0.33		0.46	

(1) The density of organisms in the size class ≥50 µm in test cycle F-2 was below the requirements of MEPC.300(72). However, DNV evaluated and found that the density of organisms in the size class ≥50 µm in the source water in this test cycle does not constitute a significant reduction in challenge conditions given that the deviations in challenge conditions were only 9%.
(2) Two test cycles were performed on the same day using the same control water tank.

Table 7 Test water conditions and operational parameters in additional land-based testing at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark, from July to August 2021 with a CompactClean BWMS with a TRC of 510 m^3/h operated in IMO mode and equipped with a UV unit V20086 and a BOLLFILTER aquaBoll BWT BB DN250 filter

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [days]	Average UVI at ballasting [W/m^2]	Average flow rate before filtration [m^3/h]
F-7	19	0.46	41	18	7.7	70	1	240 ± 1	138
F-8	20	0.46	41	18	7.7	70	1	240 ± 2	137
B-7	22	16	69	9.4	9.2	63	1	722 ± 7	461
B-8	22	16	69	9.4	9.2	63	1	709 ± 7	452
M-7	19	28	75	8.0	6.8	48	1	934 ± 2	513
M-8	19	28	75	8.0	6.8	48	1	930 ± 2	513

Table 8 Average numbers of live organisms in inlet and treated discharge water during additional land-based testing from July to August 2021. Live organisms ≥10 and <50 µm in the inlet water were quantified by microscopy counting after staining with CMFDA/FDA. Viable organisms ≥10 and <50 µm in discharge water were quantified by MPN Dilution Culture + Motility. All counts of pathogenic bacteria (*E. coli*, Enterococci and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

	Organism densities in influent water		Organism densities in discharge water			
	Organisms ≥50 µm [organisms/m^3]	Organisms ≥10-<50 µm [organisms/mL]	Organisms ≥50 µm [organisms/m^3]		Organisms ≥10-<50 µm [organisms/mL]	
Test cycle			Treated	Control	Treated	Control
F-7	654 450	2 858	1.7	271 653 (1)	0.25	>2700 (1)
F-8	593 472	2 996	0.33		0.11	
B-7	503 900	1 139	1	318 727 (1)	0.49	>2700 (1)
B-8	460 552	1 252	0.33		0.66	
M-7	141 536	1 658	0.33	85 067 (1)	3 (2)	>2700 (1)
M-8	157 247	1 540	0		5	

(1) Two test cycles were performed on the same day using the same control water tank.
(2) The MPN determined in the treated discharge water of test cycle M-7 was considered invalid due to a contamination. Therefore, the result from quantifying life organisms ≥10-<50 µm by microscopy counting after staining with CMFDA/FDA was applied for evaluation of test cycle M-7.

Shipboard testing

Table 9 Test water conditions and operational parameters in shipboard testing from November 2017 to June 2018 with a CompactClean BWMS with TRC of 1000 m^3/h operated in US mode and equipped with a UV unit V35246 and a Filtrex filter ACB-999-350 on board the general cargo ship PROVIDANA (IMO No. 9380788)

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [hr]	Average UVI at ballasting [W/m^2]	Average flow rate before filtration [m^3/h]
1	11	7.9	86	3.7	<0.17	11	23	1 062 ± 16	993
2	16	28	93	1.2	0.34	10	143	1 027 ± 94	983
3	15	28	93	1.2	0.35	30	131	1 061 ± 9	986
4	24	37	91	1.0	0.33	54	67	702 ± 12	836
5	23	37	95	0.99	0.21	48	45	840 ± 5	991

Table 10 Average numbers of live organisms in inlet and treated discharge water during shipboard testing. 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.

	Organisms ≥50 µm [organisms/m^3]		Organisms ≥10-<50 µm [organisms/mL]	
Test cycle	Influent water	Treated discharge	Influent water	Treated discharge
1	15 395	1.3	114	0.17
2	10 911	1.1	153	0.33
3	12 749	2.4	106	0.17
4	32 677	1.2	109	0.17
5	29 207	5.0	106	0.17