

TYPE APPROVAL CERTIFICATE

This is to certify:**That the Ballast Water Management System**

with type designation(s)

BalClor ® Ballast Water Management System

Issued to

**SunRui Marine Environment Engineering Co.,Ltd.
QINGDAO, China**

is found to comply with

DNV GL rules for classification – Ships**DNV GL class programme DNVGL-CP-0209 – Type approval – Ballast water management systems****IMO Resolution MEPC.279(70) - 2016 GUIDELINES FOR APPROVAL OF BALLAST WATER MANAGEMENT SYSTEMS (G8)****Resolution MEPC.169(57)****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 Guidelines contained in Resolution MEPC.279(70) and DNV GL Rules stated above. This Certificate is valid only for the Ballast Water Management System referred to above.

For the compliance with the resolution MEPC.279(70), 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 GL, unless otherwise instructed by relevant Maritime Administrations.

Operating media:Issued at **Høvik** on **2018-04-06**This Certificate is valid until **2021-02-12**.for **DNV GL**DNV GL local station: **Qingdao**Approval Engineer: **Tone Knudsen Fiskeseth**

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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.



Job Id: **262.1-011439-6**
Certificate No: **TAP00001BB**

Ballast Water Management System Supplier

SunRui Marine Environment Engineering Co., Ltd.

Type and Model Designation

BalClor® BWMS BC-150, BC-300, BC-500, BC-1000, BC-1500, BC-2000, BC-2500, BC-3000, BC-3500 and BC-4000, BC-5000, BC-6000, BC-7000, BC-8000.

Place of production; SunRui Marine Environment Engineering Co.,Ltd, Qingdao, China.

Equipment / Assembly drawings

The Ballast Water Management System (BWMS) shall be installed in accordance with one of the piping and instrumentation diagram listed below.

Description	Title	Drawing Nr	Rev
Piping and instrumentation diagram when using a salinity source tank	P&ID for BalClor BWMS with fresh water treatment option 1	BWMS-PDG-01	1.5
Piping and instrumentation diagram when using a brine injection system	P&ID for BalClor BWMS with fresh water treatment option 2	BWMS-PDG-02	1.5
Piping and instrumentation diagram when using a drain tank for TRO waste water	P&ID for BalClor BWMS with TRO analyser drain option 2	BWMS-PDG-03	1.1
Piping and instrumentation diagram for installation in hazardous area	P&ID for BalClor BWMS in oil tanker	BWMS-PDG-11	1.1
Installation requirements for location of TRO sampling	Distance requirement for TRO sampling BC-150~BC-8000 BalClor BWMS	BWMS-PDG-21	1.1

Product description

Treatment sequence:

- Ballast water uptake: Filtration and electrolysis
- Ballast water discharge: TRO monitoring and neutralization

BalClor® is approved with 3 alternative filters, 14 sizes of electrolyse cells and instrumentation as described in this certificate.

System design limitations

This equipment has been designed for operation in the following conditions:

Temperature and Salinity

Temperature and salinity of the ballast water is not a limiting condition for the ballast water treatment system.

The type approved system requires the electrolysis feed water to hold a salinity above 15 PSU and temperature above 5°C. In cases where the supply source falls below these limit, alarm will be given and heating or an alternative water source shall be used.

Holding time

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The system is considered to have no limitation to holding time. The system has been tested successfully with ≥ 24 hours between uptake and discharge.

Dosing of active chlorine

The TRO level during ballast water uptake must be on average 7.5 mg/L Cl_2 , and not exceed average 9 mg/L as Cl_2 .

TRC - EDU

The electrolysis unit (EDU) is designed for the flow rates below.

Model	Treatment Rated Capacity (m^3/h)	Electrolyser model/Number of cells
EDU-150	170	E1 / 4 cells
EDU-300	350	E1 / 8 cells
EDU-500	600	E2 / 12 cells
EDU-1000	1200	E3 / 12 cells
EDU-1500	1700	E3 / 12 cells
EDU-2000	2200	E4 / 12 cells
EDU-2500	2800	E4 / 18 cells
EDU-3000	3200	E4 / 18 cells
EDU-3500	3800	E5 / 24 cells
EDU-4000	4300	E5 / 24 cells
EDU-5000	5500	E5 / 32 cells
EDU-6000	6300	E5 / 40 cells
EDU-7000	7300	E5 / 40 cells
EDU-8000	8500	E5 / 48 cells

The BalClor® Model BC-300 was used during land-based tests and Model BC-3000 during shipboard tests. Additional tests were performed on the Model BC-1500, BC-2000, BC-3000 and BC-4000, on marine and brackish water conditions to confirm their ability to generate enough TRO to reach the levels defined by this Certificate. All tests were surveyed by DNV GL.

The type approved system includes three filter options for the BalClor system from Boll & Kirch, SunRui Luoyang and Filtersafe. Filter size shall be selected according to ballast flow capacities as shown below.

TRC - Boll & Kirch Filter

The Bollfilter Selfclean type 6.18.2 is a candle filter with 50 μm wire mesh manufactured by Boll & Kirch. Additional land-based tests of the BalClor® BWMS with this filter installed were carried out and surveyed by DNV GL. Bollfilter Automatic Filter type 6.18.3C can replace type 6.18.2.

Backwash shall initiate when a differential pressure over the filter is ≥ 0.38 bar.

Boll & Kirch Type	Standard Size	Min flow rate (m³/h)	Max flow rate (m³/h)	Minimum back-pressure
6.18.3	200	85	320	1.5 Bar
6.18.3	250	85	425	1.5 Bar
6.18.3	300	85	640	1.5 Bar
6.18.3	400	170	1200	1.5 Bar
6.18.3	500	205	1800	1.5 Bar
6.18.3	600	215	2200	1.5 Bar
6.18.3	700	330	3280	1.5 Bar
6.18.3	800	440	4000	1.5 Bar
6.18.3	900	440	4730	1.5 Bar

TRC – SunRui Luoyang

The filter type SRF-series manufactured by SunRui Luoyang is a screen filter with a 50µm wire mesh. 9 land-based tests of the BalClor® BC-300 with the SRF-400H filter installed were carried out and surveyed by DNV GL.

Backwash shall initiate when a differential pressure over the filter is ≥ 0.4 bar.

Luoyang Sunrui	Standard Size	Min flow rate (m³/h)	Max flow rate (m³/h)	Minimum back-pressure
SRF-100H/SRF-100V	DN80-150	20	100	1.6 Bar
SRF-200H/SRF-200V	DN250/200/150	40	200	1.6 Bar
SRF-400H/SRF-400V	DN300/250/200	80	400	1.6 Bar
SRF-600H/SRF-600V	DN350/300/250	120	600	1.6 Bar
SRF-800H/SRF-800V	DN400/350/300	160	800	1.6 Bar
SRF-1200H/SRF-1200V	DN450/400/350	240	1200	1.6 Bar
SRF-1600H/SRF-1600V	DN500/450/400	320	1600	1.6 Bar
SRF-2000H/SRF-2000V	DN600/500/450	400	2000	1.6 Bar
SRF-2500H/SRF-2500V	DN600/500/450	500	2500	1.6 Bar
SRF-3500H/SRF-3500V	DN700/600/500	700	3500	1.6 Bar

TRC - Filtersafe

The filter type BS-Series manufactured by Filtersafe is a screen filter with a 50µm wire mesh. A full set of land-based tests of the BalClor® BC-300 with the BS0151 filter installed were carried out and surveyed by DNV GL. A full set of shipboard tests of the BalClor® BC-3000 with the BS1204-T filter installed were carried out and surveyed by DNV GL.

Backwash shall initiate when a differential pressure over the filter is ≥ 0.4 bar.

Filtersafe	Standard Size	Min flow rate (m³/h)	Max flow rate (m³/h)	Minimum back-pressure
BS-025 H/V	DN50-100	10	50	1.6 Bar
BS-031 H/V	DN50-100	10	75	1.6 Bar
BS-050 H/V	DN80-150	20	125	1.6 Bar
BS-061 H/V	DN80-150	20	150	1.6 Bar
BS-061 H/V-T	DN80-150	22	150	1.6 Bar
BS-070 H/V	DN150-200	20	180	1.6 Bar
BS-100 H/V	DN150-200	30	250	1.6 Bar
BS-100 H/V-T	DN200-250	37	250	1.6 Bar
BS-101 H/V	DN150-200	20	250	1.6 Bar
BS-101 H/V-T	DN200-300	22	250	1.6 Bar
BS0150	DN200-250	30	375	1.6 Bar
BS0150-T	DN200-300	37	375	1.6 Bar
BS0151	DN200-300	30	375	1.6 Bar
BS0151-T	DN250-350	37	375	1.6 Bar

Filtersafe	Standard Size	Min flow rate (m ³ /h)	Max flow rate (m ³ /h)	Minimum back-pressure
BS200	DN250-350	40	500	1.6 Bar
BS200-T	DN250-350	44	500	1.6 Bar
BS201	DN250-350	40	500	1.6 Bar
BS201-T	DN250-350	44	500	1.6 Bar
BS300	DN250-350	40	750	1.6 Bar
BS300-T	DN300-400	44.4	750	1.6 Bar
BS400	DN300-400	50	1000	1.6 Bar
BS400-T	DN300-400	59.2	1000	1.6 Bar
BS603	DN400-450	120	1500	1.6 Bar
BS603-T	DN400-450	133.2	1500	1.6 Bar
BS804	DN450-500	160	2000	1.6 Bar
BS804-T	DN450-500	178	2000	1.6 Bar
BS1004	DN500-600	200	2500	1.6 Bar
BS1004-T	DN500-600	237	2500	1.6 Bar
BS1204	DN500-600	240	3000	1.6 Bar
BS1204-T	DN500-600	296	3000	1.6 Bar
BS1206	DN500-600	240	3000	1.6 Bar
BS1206-T	DN500-600	266	3000	1.6 Bar
BS1406	DN500-600	300	3500	1.6 Bar
BS1406-T	DN500-600	355	3500	1.6 Bar

Operational specifications for the different components

Saline water source

The system is arranged to give alarm in case the salinity is lower than 15 PSU in the feedwater to the electrolysis unit. The operator then needs to switch to a high salinity source for the feedwater. The feedwater needs to be pre-filtered water.

The arrangement and details of the saline water source must be approved on a case by case basis.

The system has an option for installation of a brine injection system. The brine injection system includes a sea water holding tank, a brine holding tank and a pump. The flow of the brine injection is monitored by a flow meter, but must be adjusted manually according to the manual.

Water temperature

The system is arranged to give alarm in case the temperature is lower than 5°C in the feedwater to the electrolysis unit. The heat source must be approved on a case by case basis.

TRO (Total Residual Oxydants) meter

The type approved system includes TRO meters that monitor TRO levels during uptake and before discharge.

The control equipment has been designed and tested to keep the TRO level at 7.5 mg/L Cl₂ during ballasting and at less than 0.1 mg/L Cl₂ before discharge.

The TRO meter listed under Control and Monitoring Equipment, tested and verified during land-based and shipboard tests, is covered by this type approval.

Neutralization unit

The type approved system includes a neutralizer with Na₂S₂O₃·5H₂O that is injected automatically to ensure that discharged treated water does not exceed the TRO limit of 0.1 mg/L Cl₂.

Hydrogen degas evacuation

The approved system includes a cyclone and degas ventilation arrangement with two blowers arranged independently and connected to emergency power.

Control and monitoring equipment

The type approved system includes a temperature sensor, salinity meter and a flow meter on the electrolyser feed flow. The pressure inside the electrolyzers is monitored at the inlet and is arranged with an independent shutdown functionality. The cyclone and degas arrangement includes an air pressure sensor and hydrogen detector. Hydrogen detector(s) and chlorine detector(s) shall be installed in the vicinity of the electrolyser. The filter in the main ballast line includes differential pressure monitoring, flow meter before or after the filter and a flow control valve.

Information regarding the selected components shall be part of the documentation related to the specific installation, either by a reference to valid type approval certificate or technical documentation.

The Type Approved system includes the following control units:

Name	Manufacturer	Model	Software revision
TRO meter	HF Scientific, USA	CLX-XT, CLX-Ex or CLX-Ex2	N/A
Control unit	SunRui Marine Environment Engineering Co., Ltd	SCC-1	N/A
Rectifier	SunRui Marine Environment Engineering Co., Ltd	SCR-01X1, SCR-01A1, SCR-01B1, SCR-01C1, SCR-01D1, SCR-01E1, SCR-01F1, SCR-01G1, SCR-01H1, SCR-01J1,	N/A
PLC program	SunRui Marine Environment Engineering Co., Ltd	Q series and CJ series	BC.02.XX

All changes in software are to be recorded as long as the system is in use onboard. The records of all changes are to be forwarded to DNV GL for evaluation and approval. Major changes in the software are to be approved before being installed in the computer. Based on the modification, a Certification of Application Functions may be required for the particular vessel.

The rectifier cabinet shall be presented with an IP test report.

Documents approval

The following documentation is to be submitted for approval in each case:

Control and instrumentation:

- Power supply arrangement
- Interface description specifying external signals 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 Pt.4, Ch.8, Sec.11 for components in possible contact with hydrogen gas (blowers, air pressure sensor, Hydrogen detector)
- List of Ex equipment according to Pt.4, Ch.8, Sec.11 if the system is to be installed in hazardous zone

Piping:

- Piping and Instrumentation Diagram (P&ID) of the ballast system including the treatment system Installation

Tests carried out

- Land-based testing in accordance with Resolution MEPC.174(58) and 46CFR 162.060-26
- Shipboard testing in accordance with Resolution MEPC.174 (58) and 46 CFR 162.60-28
- Factory Acceptance Test of the control and automation system witnessed by DNV
- Environmental testing in accordance with Environmental test specification for instrumentation and automation equipment, DNV Standard for Certification No. 2.4 (April 2006) and Resolution MEPC.174 (58)
- Land-based testing for alternate filters in accordance with Resolution MEPC.174(58) and 46CFR 162.060-26 but limited to 3 tests in each salinity
- Bench-scale testing of scaled units witnessed by DNV GL

Marking of product

For Traceability of this type approval, each treatment system is to be marked with:

- Manufacturer's name or trade mark
- Type designation
- Serial number

Periodical assessment

DNV GL's surveyor is to be given permission to perform Periodical Assessments at any time during the validity of this certificate and at least every second year. The arrangement is to be in accordance with procedure described in DNV GL-CP-0338 Section 4.

The scope of periodical assessment includes:

- Ensure that type approved documentation is available
- Inspection of factory samples, selected at random from the production line (where practicable)
- Review of production and inspection routines, including test records from product sample tests and control routines
- Ensuring that systems, software versions, components and/or materials used comply with type approved documents and/or referenced system, software, component and material specifications
- Review of possible changes in design of systems, software versions, components, materials and/or performance, and make sure that such changes do not affect the type approval given
- Ensuring traceability between manufacturer's product type marking and the type approval certificate

ANNEX 1 SUMMARY OF TESTING

Summary of land-based testing for Sunrui, BalClor using BC-300 reactor size 350 m³/h and Filtersafe BS-150H-10 with a 50 µm mesh screen, 2015.

Table 1 Test water conditions in fresh, brackish and marine water test cycles.

Test cycle	Salinity (PSU)	Temp. (°C)	TRO (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVT (%)	Average flow rate (m ³ /h)	Hold time (day)
F-1	0.38	18	8.3±3.1	7.7	7.2	67	41	263	5
F-2 ¹⁾	0.36	18	8.0±3.2	7.9	7.1	75	39	269	1
F-3 ¹⁾	0.36	18	7.6±3.9	7.9	7.1	75	39	268	1
F-4 ¹⁾	0.41	18	8.0±1.3	6.0	7.0	61	45	267	5
F-5 ¹⁾	0.41	19	8.0±1.8	6.0	7.0	61	45	265	5
B-1	17	17	7.9±1.1	7.3	7.4	52	63	305	5
B-2 ¹⁾	19	16	7.9±0.8	7.4	8.0	59	61	305	1
B-3 ¹⁾	18	16	7.9±0.7	7.4	8.0	59	61	304	1
B-4 ¹⁾	18	15	7.8±0.8	7.3	8.3	57	61	301	5
B-5 ¹⁾	18	15	7.6±0.8	7.3	8.3	57	61	304	5
M-1 ¹⁾	32	10	8.1±1.3	6.9	7.8	57	62	308	1
M-2 ¹⁾	32	10	10±0.8	6.9	7.8	57	62	309	1
M-3 ¹⁾	34	11	7.9±1.8	6.6	8.2	45	69	306	5
M-4 ¹⁾	34	11	7.8±1.6	6.6	8.2	45	69	303	5
M-5	34	5.7	8.1±1.1	6.7	7.8	46	66	305	5

1) 2 test cycles run in parallel using the same control

Table 2 Average numbers (three replicates) of live organisms in inlet, treated and control discharge waters. Live organisms ≥ 10 and $< 50 \mu\text{m}$ were quantified by most probable number assay (MPN). All counts of pathogenic bacteria (*E. coli*, enterococci and *Vibrio cholerae*) in the test cycles were below the ballast water discharge standard.

Test cycle	Organisms $\geq 50 \mu\text{m}$ (organisms/ m^3)	Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	Organisms $\geq 50 \mu\text{m}$ (organisms/ m^3)		Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	
			Treated	Control	Treated	Control
	Inlet to BWMS	Inlet to BWMS FDA/CMFDA			FDA/ CMFDA	FDA/ CMFDA
F-1	210,137	13,213	0	83,141	3.1	2,320
F-2 ¹⁾	447,752	24,418	0	198,601	8.9	3,227
F-3 ¹⁾	447,752	24,418	0	198,601	6.1	3,227
F-4 ¹⁾	196,436	27,705	0.67	172,769	1.6	1,927
F-5 ¹⁾	196,436	27,705	0.33	172,769	0.89	1,927
B-1	178,499	1,618	0	27,787	0.78	837
B-2 ¹⁾	207,693	2,827	1.0	119,412	0.89	1,089
B-3 ¹⁾	207,693	2,827	0	119,412	0.67	1,089
B-4 ¹⁾	172,639	1,818	0	36,162	0.56	4,807
B-5 ¹⁾	172,639	1,818	0	36,162	0.78	4,807
M-1 ¹⁾	190,928	1,708	0.67	85,327	0.44	1,357
M-2 ¹⁾	190,928	1,708	0.33	85,327	0.11	1,357
M-3 ¹⁾	199,537	1,562	0	66,408	0.33	3,769
M-4 ¹⁾	199,537	1,562	0	66,408	0	3,769
M-5	167,507	1,980	0.33	26,065	0.22	1,613

1) 2 test cycles run in parallel using the same control

Job Id: **262.1-011439-6**
Certificate No: **TAP00001BB**

Summary of additional land-based testing for Sunrui, BalClor using BC-300 reactor size 350 and Sunrui Luoyang SRF-400H with a 50 µm mesh screen, 2016

Table 3 Test water conditions in fresh, brackish and marine water test cycles.

Test cycle	Salinity (PSU)	Temp. (°C)	TRO (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVT (%)	Average flow rate (m³/h)	Hold time (day)
F-6	0.37	18	7.6±1.1	7.2	7.2	55	50	350	1
F-7	0.39	19	7.5±1.2	7.2	6.4	58	51	353	5
F-8	0.42	20	7.5 ±1.0	6.2	6.4	60	52	351	1
B-6	17	7.4	7.4 ±0.9	7.6	8.2	66	63	351	1
B-7	17	12	7.5 ±0.5	7.5	7.9	56	64	351	1
B-8	17	13	7.5 ±0.4	7.5	7.9	56	64	351	1
M-6	29	15	7.6 ±0.4	7.1	6.0	40	70	353	1
M-7	28	18	7.4 ±0.6	7.3	7.2	43	68	351	1
M-8	28	19	7.6 ±0.7	7.3	7.2	43	68	352	1

Table 2 Average numbers (three replicates) of live organisms in inlet, treated and control discharge waters. All counts of pathogenic bacteria (*E. coli*, enterococci and *Vibrio cholerae*) in the test cycles were below the ballast water discharge standard.

Test cycle	Organisms $\geq 50 \mu\text{m}$ (organisms/m ³)	Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	Organisms $\geq 50 \mu\text{m}$ (organisms/m ³)		Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	
			Treated	Control	Treated	Control
	Inlet to BWMS	Inlet to BWMS FDA/CMFDA			FDA/ CMFDA	FDA/ CMFDA
F-6	148,556	4,134	0	151,064	0.56	2,687
F-7	619,919	5,997	0	205,323	0.67	1,110
F-8	362,255	2,849	0	356,009	0.33	770
B-6	221,569	1,004	0.33	174,810	0	1,000
B-7	353,847	1,771	1.3	250,916	0.33	1,248
B-8	353,847	1,771	1.7	250,916	0	1,248
M-6	325,600	1,727	0.33	137,963	0.78	800
M-7	316,869	5,480	0.33	41,965	0.22	825
M-8	316,869	5,480	0	41,965	1.0	825

Summary of additional land-based testing for Sunrui, BalClor using BC-300 reactor size 350 and Boll&Kirch 6.18.3C size 200 with a 50 µm mesh screen, 2017

Table 5 Test water conditions in fresh, brackish and marine water test cycles.

Test cycle	Salinity (PSU)	Temp. (°C)	TRO (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVT (%)	Average flow rate (m³/h)	Hold time (day)
F-10 ²⁾	0.36	16	8.1±1.4	7.4	6.5	59	48	351	1
F-11 ¹⁾	0.40	6.3	7.3±2.6	7.2	7.0	61	50	286	1
F-12 ¹⁾	0.40	6.3	7.0±3.1	7.2	7.0	61	50	288	1
B-10 ^{1) 2)}	20	10	7.2±1.3	7.6	7.0	64	64	352	1
B-11 ^{1) 2)}	20	10	7.2±1.8	7.6	7.0	64	64	342	1
B-12 ²⁾	19	9.0	6.4±3.6	6.9	7.9	62	70	339	1
M-10 ²⁾	28	9.5	7.4±2.5	6.9	6.0	45	63	335	1
M-11 ²⁾	29	6.1	5.8±1.9	7.0	6.3	46	62	359	5
M-12 ²⁾	29	6.1	6.0±1.3	7.0	6.3	46	62	381	5
M-13 ¹⁾	28	5.1	7.6±0.7	6.3	5.7	37	63	315	5
M-14 ¹⁾	28	5.0	7.0±1.4	6.3	5.7	37	63	308	5

1) 2 test cycles run in parallel using the same control

2) Test performed with higher flow rate>TRC

Table 6 Average numbers (three replicates) of live organisms in inlet, treated and control discharge waters. All counts of pathogenic bacteria (*E. coli*, enterococci and *Vibrio cholerae*) in the test cycles were below the ballast water discharge standard.

Test cycle	Organisms $\geq 50 \mu\text{m}$ (organisms/ m^3)	Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	Organisms $\geq 50 \mu\text{m}$ (organisms/ m^3)		Organisms ≥ 10 and $< 50 \mu\text{m}$ (organisms/mL)	
			Treated	Control	Treated	Control
	Inlet to BWMS	Inlet to BWMS FDA/CMFDA			FDA/CMFDA	FDA/CMFDA
F-10	152,856	2,201	2.2	58,166	0	999
F-11 ¹⁾	138,676	1,137	0	95,591	0	745
F-12 ¹⁾	138,676	1,137	0	95,591	0.11	745
B-10 ¹⁾	114,959	16,269	0.33	60,486	0.11	876
B-11 ¹⁾	114,959	16,269	0	60,486	0.11	876
B-12	214,892	2,979	0.33	67,593	1.0	1,630
M-10	175,201	4,138	1.3	49,081	0.22	1,994
M-11 ²⁾	101,700	1,298	16	22,266	0	1,612
M-12 ²⁾	101,700	1,298	14	22,266	0	1,612
M-13 ¹⁾	160,722	1,226	0	70,350	4.2	607
M-14 ¹⁾	160,722	1,226	0	70,350	0	607

1) 2 test cycles run in parallel using the same control

2) Test failed to meet the discharge standard for organisms $\geq 50 \mu\text{m}$

Summary of shipboard testing for Sunrui, Balclor BC-3000, size reactor size 350 using Filtersafe filter model BS1204-T with a 50 µm mesh screen, 2015-2016

Table 7 Flow rate, UVT, UVI, average numbers (three replicates) of live organisms in inlet and treated discharge waters. All counts of pathogenic bacteria (*E. coli*, enterococci and *Vibrio cholerae*) in the test cycles were below the ballast water discharge standard.

Test cycle	Average flow rate during ballast operation (m ³ /h)	TRO mg/L	Salinity	UVT	Temperature	Organisms ≥50 µm per m ³		Organisms ≥10 and <50 µm per mL; Algal re-growth + CMFDA/FDA-stained motile organisms	
						Inlet	Discharge	Inlet FDA/CMFDA	Discharge FDA/SMFDA
1	3,046	NR	32	93	24	33,217	8.4	45	0
2	3,027	7.1±0.8	33	95	30	28,355	1.8	26	0.22
3	3,029	6.9±1.0	33	96	30	32,560	1.6	110	1
4	3,005	7.0±0.2	33	95	29	38,373	1.0	560	0.44
5	3,007	7.0±0.5	33	96	28	41,012	3.3	370	0.56
6	3,034	6.7±0.7	37	98	25	24,400	2.7	109	0
7	3,041	6.9±0.1	37	97	26	25,913	5.3	110	0.17

Copy of type approval certificate

A copy of this type approval certificate should be carried onboard a vessel fitted with this Ballast Water Management System at all times. A reference to the test protocol and a copy of the test results should be available for inspection onboard the vessel.

END OF CERTIFICATE