

TYPE APPROVAL CERTIFICATE

This is to certify:

That the **Ballast Water Management System**

with type designation(s)
NGT BWMS (models DL1-BK273 to D5XL18-BK750)

Issued to

Norwegian Greentech AS
Fosnavåg, Norway

is found to comply with

IMO Resolution MEPC.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)
DNV GL class programme DNVGL-CP-0209 – Type approval – Ballast water management systems
DNV GL 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 **2021-06-15**

for **DNV**

This Certificate is valid until **2025-12-08**.

DNV local station: **Ulsteinvik**

Approval Engineer: **Michael Lehmann**

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.



Name of ballast water management system (BWMS)

NGT BWMS

The NGT BWMS was initially type approved by DNV on 2020-12-09 on behalf of the Norwegian Maritime Authority (DNV type approval certificate no. TAP000028V).

Ballast water management system manufactured by

Norwegian Greentech AS

Place of production

Norwegian Greentech AS, 6092 Fosnavåg, Norway

Type and model designations

NGT BWMS models DL1-BK273, DL2-BK273, DL3-BK324, DL4-BK324, DL4-BK356, DXL6-BK356, DXL9-BK356, DXL9-BK419, DXL12-BK419, D4XL8-BK419, D4XL10-BK419, D4XL10-BK521, D4XL10-BK600, D4XL12-BK600, D4XL12-BK750, D5XL14-BK750, D5XL16-BK750 and D5XL18-BK750.

Equipment / Assembly drawings

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

Type	Title	Drawing no.	Revision
Operation, maintenance and safety manual (OMSM)	NGT BWMS user documentation Part I: Installation manual	IM	B
	NGT BWMS user documentation Part II: Operation, Safety & Maintenance manual	OSMM	C
Piping and instrumentation diagrams (P&ID)	P&ID for NGT BWMS	DL1-BK273	A
		DL2-BK273	B
		DL3-BK324	B
		DL4-BK324	B
		DL4-BK356	B
		DXL6-BK356	B
		DXL9-BK356	B
		DXL9-BK419	B
		DXL12-BK419	B
		D4XL8-BK419	B
		D4XL10-BK419	B
		D4XL10-BK521	B
		D4XL10-BK600	A
		D4XL12-BK600	A
		D4XL12-BK750	A
D5XL14-BK750	A		
D5XL16-BK750	A		
D5XL18-BK750	A		
Bill of materials (BoM)	Bill of Materials for NGT BWMS	DL1-BK273	C
		DL2-BK273	C
		DL3-BK324	C
		DL4-BK324	C
		DL4-BK356	C
		DXL6-BK356	C
		DXL9-BK356	C
		DXL9-BK419	C
		DXL12-BK419	C
		D4XL8-BK419	C
D4XL10-BK419	C		

		D4XL10-BK521	D0700	C
		D4XL10-BK600	D0800	C
		D4XL12-BK600	D0810	C
		D4XL12-BK750	D0900	C
		D5XL14-BK750	D01000	C
		D5XL16-BK750	D01100	C
		D5XL18-BK750	D01200	C
Electrical diagrams	Control cabinet	DL1-BK273 – DXL9-BK356	C3100-04 (380-440V) C3100-06 (690V)	A
		DXL9-BK419 – D4XL12-BK600	C3200-04(380-440V) C300-06 (690V)	A
		D4XL12-BK750 – D5XL18-BK750	C3300-04(380-440V) C3300-06 (690V)	A
	Wiring diagram		E3XX0-04-1800 ⁽¹⁾ (380-440V) E3XX0-06-1800 ⁽¹⁾ (690V)	A
General arrangement (GA) drawings	Dimensional sketch for NGT BWMS	DL1-BK273	D0050-11-02	-
		DL2-BK273	D0100-11-02	-
		DL3-BK324	D0200-11-02	A
		DL4-BK324	D0210-11-02	-
		DL4-BK356	D0300-11-03	-
		DXL6-BK356	D0400-11-02	-
		DXL9-BK356	D0410-11-02	-
		DXL9-BK419	D0420-11-01	-
		DXL12-BK419	D0500-11-01	A
		D4XL8-BK419	D0600-11-01	A
		D4XL10-BK419	D0610-11-01	A
		D4XL10-BK521	D0700-11-01	A
		D4XL10-BK600	D0800-11-01	A
		D4XL12-BK600	D0810-11-01	A
		D4XL12-BK750	D900-11-01	-
		D5XL14-BK750	D1000-11-01	-
D5XL16-BK750	D1100-11-01	-		
D5XL18-BK750	D1200-11-01	-		

(1) For the wiring diagrams, XX is either 40, 41, 42, [...], 56 or 57 depending on the BWMS model. Wiring diagrams have the drawing numbers E3XX0-0401-1800 or E3XX0-0601-1800 when the BWMS is equipped with the optional electrically actuated wiper system.

Other equipment manufactured by

The NGT BWMS applies UV chambers of the DeltaLine series manufactured by bestUV and filters of the aquaBoll 6.18.3 series with 20 µm mesh screen manufactured by Bollfilter Nordic.

Treatment Rated Capacity

30 – 1274 m³/h

Product description

Treatment sequence:

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

System design limitations / Water quality parameters

Temperature & salinity

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

System design limitations / Operational parameters

Holding time

The NGT BWMS 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

At high UV transmittance (UVT) levels, the BWMS reduces the power to the UV lamps in steps from 100% down to 60%.

At lower UVT levels, the BWMS monitors the UV intensity (UVI) and is designed to adjust the flow rate by controlling the ballast water pump(s).

The applicable UVI limits are listed in the table below. The regulated flow in fresh water (salinity <1 PSU) is lower than in brackish and marine water, and the BWMS is supplied with a conductivity transmitter (CTI) to measure the salinity of the ballast water to be treated.

The BWMS may be installed without any flow control. The low UVI limit is then the low UVI error limit calculated by the BWMS based on the ballasting flow rate. For installations without flow control, the TRC of the selected BWMS model must be equal or larger than the ballast water pump(s) capacity.

UV chamber model by bestUV	UVI limit for power reduction [W/m ²]	UVI limit at full flow (TRC) ⁽¹⁾ [W/m ²]	Low UVI limit at minimum flow rate ⁽²⁾ [W/m ²]	Minimum flow rate [m ³ /h]	
				Salinity ≥1 PSU	Salinity <1 PSU
DL1	2 033	1 369	450	10	7.4
DL2	N/A	7 097	3 200	28	20
DL3	4 042	2 722	2 066	37	26
DL4	21 004	14 144	7 443	71	51
DXL6	12 768	8 598	3 173	81	58
DXL9	27 346	18 415	8 694	92	65
DXL12	23 639	15 919	6 209	178	127
D4XL8	7 918	5 332	280	180	128
D4XL10	16 559	11 151	4 023	237	169
D4XL12	25 077	16 887	7 014	310	221
D5XL14	15 297	10 301	4 109	433	308
D5XL16	17 340	11 677	4 700	518	369
D5XL18	21 525	14 495	5 515	654	414

(1) As per the CFD analyses provided, this UVI limit corresponds to an UVT in the range of 64-67% depending on the UV chamber model.

(2) Land-based tests confirmed treatment in compliance with the discharge standard at a UVT down to 46% when reducing the flow rate to 37% of TRC.

Treatment Rated Capacity

The maximum flow rates of the UV chambers models and Bollfilter aquaBoll 6.18.3 filter models applied by the NGT BWMS are listed below. The Treatment Rated Capacities (TRC) of a specific NGT BWMS model is limited by the maximum flow rate of either the selected UV chamber or the Bollfilter aquaBoll 6.18.3 filter model, whichever is lower.

UV chamber model by bestUV	TRC [m ³ /h]
DL1	30
DL2	60
DL3	90
DL4	150
DXL6	200
DXL9	260
DXL12	350
D4XL8	460
D4XL10	600
D4XL12	750
D5XL14	1005
D5XL16	1180
D5XL18	1323

Bollfilter aquaBoll 6.18.3 filter model	TRC [m ³ /h]
273	62
324	94
356	204
419	378
521	518
600	614
750	1274

Pressure

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

Minimum ballast water inlet pressure	Maximum ballast water operating pressure	Filter differential pressure triggering backflushing	Maximum filter differential pressure
1.5 bar	10 bar	0.3 bar	1.0 bar

Control and monitoring equipment

Software version

The NGT BWMS is type approved with the system control software version 4.5.X. In the software version the “4” represents the major version number of the software. A major revision of the software will be any change to the control and operating philosophy of the NGT BWMS. The “5” represents the minor version number of the software and is reserved for new or changed features which do not affect core functionality. The “X” represents the patch level which is reserved for bug fixes and graphical user interface changes.

Any changes to the software are to be recorded as long as the system is in use onboard. Records of any software changes resulting in a revision of the major or minor 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 NGT 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 transducers PT-1 and PT-2 before and after the filter;
- Flow meter FT-1 (normally located before the filter, but may also be installed after the UV chamber);
- UV chamber temperature sensor TT1.

The flow rate is monitored by the main control cabinet, while the temperature is monitored by the UV control cabinet. Both system can independently shut down the BWMS. Temperature monitoring is thus a safety function independent of the BWMS main control system.

Electrical and electronic components

The NGT BWMS is type approved with the electrical and electronic components (including the above listed instruments for monitoring safe operation of the BWMS) indicated on the P&ID and specified on the BoM. Except for the components listed below, alternate models to the ones specified on the BoM 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 below shall be used:

Tag No.	Component name	Manufacturer	Model(s)
MC1	NGT BWMS Control Cabinet	NGT	-
UVPC1	UV Control Cabinet	bestUV	-
UVL1-18	UV lamps	bestUV	C1500, C3000, C3050
LT1	UV light intensity sensor	bestUV	Us3 Sensor Module

Hazardous area / Ex-proof

This type approval does not cover installations of the NGT BWMS in hazardous area.

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
- Functional test procedure (for BWMS commissioning)
- Interface description towards ship’s existing systems including alarms for failure

Type approval documentation

Test plan and reports:

- NIVA: Land-based testing of the Ballast Water Management System of Norwegian Greentech AS (Report Serial No. 7488-2020, Final report of 2020-11-18)
- NIVA: Shipboard testing of the Ballast Water Management System of Norwegian Greentech AS (Report Serial No. 7528-2020, Final report of 2020-11-09)
- Applica Test & Certification AS: Technical Report for Norwegian Greentech AS - Type testing of Ballast Water Management System – BWMS (Report no. 30484, rev 0)
- Applica Test & Certification AS: Technical Report for Norwegian Greentech AS - EMC and Environmental testing of Flowmeters (Report no. 30484 Flowmeter, rev 0)
- DELTA: Test for Marine Type Approval of MMC Ballast Water Management System – 300 m³/h (Report no. DANAK-19/12610, 15 November 2012)

System documentation:

- Norwegian Greentech AS: NGT BWMS user documentation part I: Installation manual (Document id IM , rev B)

- Norwegian Greentech AS: NGT BWMS user documentation part II: Operation, Safety & Maintenance manual (Document id OSMM, rev C), including Appendices A-H
- bestUV: Control and operation of the UV system in NorwegianGT BWMS (04-2021)
- bestUV: Design model for NorwegianGT BWMS UV systems (03-05-2021)
- BOLLFILTER Nordic: Technical specifications for AquaBoll 6.18.3 with 20 µm fine sieve cylinder / pleated basket
- Norwegian Greentech AS: Functional test procedure (rev B)

Tests carried out

- Land-based testing with NGT BWMS model DXL9-BK419 (TRC of 260 m³/h)
- Shipboard testing with NGT BWMS model DXL12-BK419 (TRC of 345 m³/h)
- Function tests of the control and monitoring system witnessed by DNV
- Environmental testing in accordance with DNV class guidelines for Environmental test specification for electrical, electronic and programmable equipment and systems (DNVGL-CG-0339) and IACS UR E10 (rev. 6 or rev. 7)

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 onboard 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 onboard the vessel.

Revision history of this certificate

Revision No.	Date of Issuance	Description
-	2021-06-15	Initial certificate on behalf of Transport Canada. The NGT BWMS was initially type approved by DNV on 2020-12-09 on behalf of the Norwegian Maritime Authority (DNV type approval certificate no. TAP000028V).

ANNEX: SUMMARY OF TESTING

Land-based testing

Table 1 Test water conditions and operational parameters in land-based testing of the NGT BWMS model DXL9-BK419 (TRC of 260 m³/h) at NIVA's test facility at Solbergstrand, Drøbak, Norway, during the period of 3 April 2019 to 27 September 2019.

Test cycle / Salinity	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [hours]	Average UV-I at ballasting [W/m ²]	Average flow rate before filtration [m ³ /h]
3 / MW	9	32	62	8.9	6.6	60	23	18 968	253
4 / MW	9	32	63	9.1	11.0	63	23	18 895	256
5 / MW	10	33	60	10.3	7.0	58	119	13 286	195
6 / MW	10	33	58	10.3	8.4	59	119	12 553	193
9 / MW	11	32	77	7.6	7.2	45	23	17 702	234
2 / BW	6	19	59	10.7	8.2	57	119	13 132	200
7 / BW	11	20	47	13.0	>5 ⁽¹⁾	57	22	9 271	98
8 / BW	11	20	46	12.6	>5 ⁽¹⁾	58	22	8 890	95
10 / BW	12	19	65	8.3	9.3	62	119	19 888	254
11 / BW	12	19	61	8.3	9.6	68	119	19 579	258
15 / FW	16	0.0	65	8.6	6.1	53	23	18 908	256
18 / FW	14	0.1	59	10.4	6.9	53	119	12 720	200
19 / FW	14	0.1	58	10.4	6.5	52	118	12 921	196
20 / FW	12	0.0	59	7.7	7.1	53	22	13 318	96
21 / FW	12	0.0	61	7.8	6.6	53	22	13 286	99

(1) The POC concentration reported by NIVA's laboratory were 2.6 and 3.4 mg/L for the two brackish water test cycles 7 and 8, respectively. However, these POC concentrations are the result of an analytical error. The POC concentrations measured prior to augmentation was 2.3 mg/L, and the augmentation with corn starch, as per normal procedure by NIVA, has resulted in POC concentrations exceeding the 5 mg/L required by MEPC.300(72). This is confirmed by the POC concentrations reported for the corresponding treated water samples and control water samples collected during ballasting, which were 5.9, 6.9 and 8.8 mg/L, respectively.

Table 2 Average numbers of live organisms in inlet and treated discharge water during land-based testing of the NGT BWMS model DXL9-BK419. Live organisms ≥ 10 and $< 50 \mu\text{m}$ in the inlet water were quantified by microscopy counting after staining with CMFDA/FDA. Viable organisms ≥ 10 and $< 50 \mu\text{m}$ 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.

Test cycle / Salinity	Organism densities in inlet water		Organisms densities in discharge water			
	Organisms $\geq 50 \mu\text{m}$ [organisms/m ³]	Organisms ≥ 10 - $< 50 \mu\text{m}$ (CMFDA/FDA) [organisms/mL]	Organisms $\geq 50 \mu\text{m}$ [organisms/m ³]		Organisms ≥ 10 - $< 50 \mu\text{m}$ (MPN+Motility) [organisms/mL]	
			Treated	Control	Treated	Control
3 / MW	137 321	1 667	<1	170 704 ⁽¹⁾	<0.2	920 ⁽¹⁾
4 / MW	137 825	1 867	<1		<0.2	
5 / MW	4 154 908	1 143	<1	118 733 ⁽¹⁾	0.2	1 600 ⁽¹⁾
6 / MW	4 107 167	1 043	<1		<0.2	
9 / MW	138 458	3 017	0.3	126 433	0.2	>1 600
2 / BW	320 263	1 911	2.3	132 938	<0.2	>1 600
7 / BW	115 104	1 203	<1	104 979 ⁽¹⁾	0.2	>1 600 ⁽¹⁾
8 / BW	127 000	1 153	<1		<0.2	
10 / BW	127 346	3 717	0.3	76 125 ⁽¹⁾	<0.2	>1 600 ⁽¹⁾
11 / BW	140 883	3 783	0.6		<0.2	
15 / FW	166 929	1 158	5.7	180 483	1.0	1 100
18 / FW	389 421	1 808	<1	614 797 ⁽¹⁾	0.14	260 ⁽¹⁾
19 / FW	393 111	1 642	<1		0.39	
20 / FW	108 943	1 706	<1	86 325 (1)	0.21	2 700 (1)
21 / FW	126 768	1 733	<1		0.07	

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

Shipboard testing

Table 3 Test water conditions and operational parameters in shipboard testing with the NGT BWMS model DXL12-BK419 (TRC of 345 m³/h) on board the general cargo ship FRI SEA (IMO 9229166) during the period of 28 November 2019 to 23 June 2020.

Test cycle	Water temperature [°C]	Salinity [PSU]	UV-T [%]	DOC [mg/L]	POC [mg/L]	TSS [mg/L]	Holding time [hr]	Average UV-I at ballasting [W/m ²]	Average flow rate before filtration [m ³ /h]
1	17	36	97	1.1	0.3	5.0	26	29 227	156 ⁽¹⁾
3	22	22	88	2.8	0.4	<1.3	22	23 117	309
4	21	22	88	2.5	0.6	1.9	22	21 948	318
5	21	20	85	2.7	0.8	2.3	23	22 528	288
6	21	17	85	2.9	0.7	1.7	24	24 546	334

(1) The two ballast water pumps on the FRI SEA were not able to deliver a flow rate at the upper end of the BWMS TRC of 345 m³/h during test cycle 1. Prior to subsequent test cycles, one of the two ballast water pumps was replaced with a new pump, and a new third pump was temporarily installed for the purpose of shipboard testing.

Table 4 Average numbers of live organisms in inlet and treated discharge water during shipboard testing of the DXL12-BK419. 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 cycle	Organisms ≥50 μm [organisms/m ³]		Organisms ≥10-~50 μm (CMFDA/FDA) [organisms/mL]	
	Influent water	Treated discharge	Influent water	Treated discharge
1	13 998	3.0	230	2.5
3	387 237	1.3	8 016	6.5
4	337 396	4.2	8 345	5.3
5	525 406	3.5	46 028	1.8
6	42 291	1.4	2 692	1.8