

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

with type designation(s)

**Hyde GUARDIAN-US (model range HG60U to HG3000U)**

Issued to

**Calgon Carbon UV Technologies LLC, d/b/a Hyde Marine  
Coraopolis, PA, USA**

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.300(72) - Code for Approval of Ballast Water Management Systems (BWMS Code)****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 and DNV GL 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 BWMS Code, 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.**Issued at **Høvik** on **2020-01-23**for **DNV GL**This Certificate is valid until **2025-01-22**.DNV GL local station: **New York**Approval Engineer: **Martin Olofsson****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)**

Hyde GUARDIAN-US BWTS

**Ballast water management system manufactured by**

Calgon Carbon UV Technologies LLC, d/b/a Hyde Marine

**Place of production**

2000 McClaren Woods Drive, Coraopolis, PA 15108, USA

**Type and model designations**

HG60U, HG100U, HG150U, HG250U, HG300U, HG500U, HG750U, HG1000U, HG2000U, HG3000U, HG100UX, HG150UX, HG250UX, HG300UX, HG500UX, HG750UX, HG1000UX, HG2000UX, HG3000UX

(X) implies Ex-proof configuration

**Equipment / assembly drawings**

The Hyde GUARDIAN-US BWTS shall be installed in accordance with the relevant documents listed below.

<b>Description</b>	<b>Title</b>	<b>Drawing No.</b>	<b>Revision</b>
Operation, maintenance and safety manual	Hyde GUARDIAN-US BWTS Operations & maintenance manual	G800099	Rev.0 2019-12-19
Bill of materials (BoM)	Hyde GUARDIAN-US System Bill of Materials (standard and Ex)	G800112	Rev.10 2019-12-19
Overview of drawing packages	System drawing matrix	G800156	Rev.1 2019-12-19
Piping and instrumentation diagram (P&ID)	Flow schematic	G500340	Rev.0 2019-10-01
Drawings of components and arrangements	HG60U - HG1000U, HG100UX - HG1000UX Mechanical Package (one for each model)	see details in G800156	2019-12-19
Electrical wiring diagram	HG60U - HG1000U, HG100UX - HG1000UX Electrical Drawing Package (one for each model)	see details in G800156	2019-12-19

**Other equipment manufactured by**

The Hyde GUARDIAN-US BWTS applies the ACB self-cleaning screen filter series manufactured by Filtrix.

## Treatment Rated Capacity

60 - 3000 m<sup>3</sup>/h

## Product description

Treatment sequence:

- Ballast water uptake: filtration and inactivation by UV treatment
- Ballast water discharge: inactivation by UV treatment

## System design limitations / Water quality parameters

### Temperature & Salinity

Temperature and salinity of the ballast water are not limiting conditions for the ballast water management system.

## System design limitations / Operational parameters

### Holding time

Hyde GUARDIAN-US BWTS has demonstrated performance to the discharge standard with a minimum holding time between uptake and discharge of 24 hours in land-based testing. 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.

### Dosing

The system is designed to deliver satisfactory treatment at a UV dose greater than or equal to 170 mJ/cm<sup>2</sup>. The UV dose is a calculated value based upon flow rate and the measured UV intensity value from the UV sensor.

A treatment alarm is given if the minimum dose cannot be maintained by the system.

The treatment starts at 100% lamp power. If the dose is above 295 mJ/cm<sup>2</sup>, the lamp power is reduced to 60%. If the dose is below 170 mJ/cm<sup>2</sup> the flow is modulated to maintain the minimum dose at 170 mJ/cm<sup>2</sup>. The flow can be modulated down to 15% opening of the modulating valve (V4). In practice, this may imply flow reduction down to about 20% of the TRC in very turbid water.

### Treatment Rated Capacity of the BWMS

The Treatment Rated Capacities (TRC) of the designated Hyde GUARDIAN-US models are listed in the table below. The table also specifies the filter and the UV reactor that shall be installed for a specific model.

UV reactors and filter units can be installed in parallel configuration to achieve higher flow capacities according to the design and installation guide and the table below.

The BWMS controls the flow rate in the ballast water line by using a flow limiting valve to ensure that the flow rate is kept within the TRC of a specific model.

Job Id: **262.1-033203-1**  
 Certificate No: **TAP000020S**

Model name	TRC (m <sup>3</sup> /h)	Filter unit	UV unit
HG60U	60	ACB-906-100	G300808
HG100U	100	ACB-910-150	G900747D15160660 (G300811xxx160660) <sup>(1)</sup>
HG100UX	100	ACB-910-150	G300816Yyxx160660 <sup>(2)</sup>
HG150U	150	ACB-915-150	G900747D15160660 (G300811xxx160660) <sup>(1)</sup>
HG150UX	150	ACB-915-150	G300816Yyxx160660 <sup>(2)</sup>
HG250U	250	ACB-935-200	G300684D20160860 (G300811xx160860) <sup>(1)</sup>
HG250UX	250	ACB-935-200	G300816Yyxx160860 <sup>(2)</sup>
HG300U	300	ACB-945-200	G300684D20160860 (G300811xxx160860) <sup>(1)</sup>
HG300UX	300	ACB-945-200	G300816Yyxx160860 <sup>(2)</sup>
HG500U	500	ACB-955-250	G900750D25201277 (G300815xxx201277) <sup>(1)</sup>
HG500UX	500	ACB-955-250	G900753D25201277 (G300818xxx201277) <sup>(1)</sup>
HG750U	750	ACB-985-300	G900750D30201877 (G300815xxx201877) <sup>(1)</sup>
HG750UX	750	ACB-985-300	G900753D30201877 (G300818xxx201877) <sup>(1)</sup>
HG1000U	1000	ACB-999-350	G300805D40201877 (G300815xxx201877) <sup>(1)</sup>
HG1000UX	1000	ACB-999-350	G300817D40201877 (G300818xxx201877) <sup>(1)</sup>
HG2000U <sup>(3)</sup>	2000	2x ACB-999-350	2x G300805D40201877 (G300815xxx201877) <sup>(1)</sup>
HG2000UX <sup>(3)</sup>	2000	2x ACB-999-350	2x G300817D40201877 (G300818xxx201877) <sup>(1)</sup>
HG3000U <sup>(4)</sup>	3000	3x ACB-999-350	3x G300805D40201877 (G300815xxx201877) <sup>(1)</sup>
HG3000UX <sup>(4)</sup>	3000	3x ACB-999-350	3x G300817D40201877 (G300818xxx201877) <sup>(1)</sup>

- (1) Alternative assembly with fabricated UV chamber (instead of cast housing)  
 (2) Assembly with fabricated UV chamber  
 (3) Capacity of 2000 m<sup>3</sup>/h is designed with 2 identical HG1000 units in parallel  
 (4) Capacity of 3000 m<sup>3</sup>/h is designed with 3 identical HG1000 units in parallel

**Pressure**

The minimum/maximum pressure and the differential pressure initiating backflushing are listed below.

Filter type	Minimum inlet pressure (back-pressure)	Differential pressure initiating backflushing	Maximum operating pressure
Filtrex type ACB	1 bar	≥ 0.3 bar	10 bar

**Control and monitoring equipment**

**Software version**

The Hyde GUARDIAN-US BWTS is type approved with the system control software version 04.02.02.yy.

Any changes to the software are to be recorded as long as the system is in use on board. Major changes in the software, as defined in the Hyde GUARDIAN Software Quality Plan, document QP No.275 (Rev.0 dated 2019-11-20), 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 for monitoring the safe operation of the BWMS:

- Temperature sensor (TP3237, mounted in UV unit)
- Water level sensor (LMT-100, mounted in the UV unit)
- Pressure transmitter (AST4000C00010B4E1000, at the inlet and outlet of filter unit)
- Flow meter (Endress+Hausser, mounted before the UV unit)
- Temperature switch (TP3237), arranged with independent shutdown functionality (≥80°C)

**Electrical and electronic components**

The Hyde GUARDIAN-US BWTS 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 Bill of Material. 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 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, the models specified in the table shall be used:

Component name	Manufacturer	Model(s)
Control panel	Hyde Marine	G104605
Power supply panel	Hyde Marine	G103340, G103370, G103392, G104630, G103400
UVI duty sensor (UVI reference sensor)	Jenoptik	R350793
UV lamp (HG60U)	Light Sources	R350842
UV lamp	ETA Plus	R350840, R350827

## **Hazardous area / Ex-proof**

The Hyde GUARDIAN-US BWTS has been evaluated and found to be in compliance with DNV GL Rules Pt.4 Ch.8 Sec.11 for hazardous area installations. The filter (including indexing arm motor and pressure transmitters), the UV reactor, the wiper drive motor assembly, valves and flowmeter have Ex-certification and can be installed in hazardous area zone 1, gas group IIC and temperature class T4. The power supply panel and the control panel are to be located in a safe zone. Ex-certification is not covered by this certificate. Installation 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.

## **Documents approval**

The following documentation is to be submitted 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 the 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 GL Rules Pt.4 Ch.8 Sec.11 if the system is to be installed in hazardous area zone
- Commissioning checklist
- Class survey checklist

## **Type Approval documentation**

### **System descriptive documentation**

- Hyde GUARDIAN-US BWTS Operations & maintenance manual, Hyde Marine, Rev.0, 2019-12-19
- G800112 Bill of Materials, Hyde Marine, Rev.10, 2019-12-19
- G800156 Hyde BWTS system drawing matrix, Hyde Marine, Rev.1, 2019-12-19
- CFD analysis for scale-up of the Hyde GUARDIAN BWMS, Hyde Marine, Rev.7, June 2019
- GUARDIAN scaling: Filter sizing, Hyde Marine, 2019-11-11
- GUARDIAN scaling: Power sizing, Hyde Marine, 2019-11-15
- Hyde GUARDIAN software quality plan, QP No. 275, Hyde Marine, Rev.0, 2019-11-20
- ISO Management System Certificate, ISO 9001:2015, issued by DNV GL 2010-11-04
- Commissioning checklist for Hyde GUARDIAN-US, Hyde Marine, Rev.1, 2019-10-15
- Class survey checklist for Hyde GUARDIAN-US, Hyde Marine, Rev.1.0, 2020-01-23

### **Biological efficacy test plans and test reports**

- Biological efficacy performance of Hyde GUARDIAN-US in land-based test – Test Plan, DHI, 2018-07-09.
- Performance evaluation of Hyde GUARDIAN-US in shipboard test – Test Plan, DHI, 2018-11-02
- Biological efficacy performance evaluation of Ballast Water Management System Hyde GUARDIAN-US HG300U in land-based test – LB test report, DHI, 2019-12-03
- Biological efficacy performance evaluation of Hyde GUARDIAN-US HG750U in shipboard test, DHI, 2019-12-18

### **Environmental test plan and reports**

- Test procedure for ballast water management system (procedure RTP-15827-1), Retlif, Rev.D, 2019-04-09
- Environmental test report, R-15827-2, Retlif, Rev.A, 2019-10-01
- EMC test report, R-15827-1, Retlif, Rev.A, 2019-12-04

### **Tests carried out**

- Land-based testing using Hyde GUARDIAN-US BWTS HG300U, with a TRC of 300 m<sup>3</sup>/h with one Filtrex ACB-945-200 filter and one G300684D20160860 UV reactor at DHI in accordance with Resolution MEPC.300(72) and USCG 46 CFR 162.060-26
- Shipboard testing using Hyde GUARDIAN-US BWTS HG750U, with a TRC of 750 m<sup>3</sup>/h with one Filtrex ACB-985-300 filter and one G300815D30201877 UV reactor on board the vessel Bore Sea (IMO 9443554) in accordance with Resolution MEPC.300(72) and USCG 46 CFR 162.060-28
- Function tests of the control and automation system witnessed by DNV GL
- Environmental testing in accordance with DNVGL-CG-0339 Standard for Certification Nov. 2015 "Environmental test specification for electrical, electronic and programmable equipment and systems", Resolution MEPC.300(72), USCG 46 CFR 162.060-30 and IACS E10

A summary of the test results from land-based and shipboard tests are given in an annex to this certificate.

### **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**

For retention of the Type Approval (TA), 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 should be carried on board 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 on board the vessel.

## ANNEX 1: SUMMARY OF TESTING

### Summary of land-based testing for Hyde GUARDIAN-US BWTS

**Table 1** Test water conditions and operational data obtained during land-based testing of the Hyde GUARDIAN-US BWTS, model HG300U with Filtrex ACB-945-200 filter (20 µm mesh size), UV reactor (8 lamps at 6.0 kW) and capacity TRC 300 m<sup>3</sup>/h, performed in the period July to October 2018 at DHI in Denmark. All water quality data are inlet samples and operational data are from ballasting operations.

Test cycle	Temp. (°C)	Salinity (PSU)	UVT <sup>(1)</sup> (%)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)	UVI <sup>(2)</sup> (mW/cm <sup>2</sup> )	UV dose <sup>(3)</sup> (mJ/cm <sup>2</sup> )	Flow rate average (m <sup>3</sup> /h)		Holding time (days)
									before filter	after filter <sup>(4)</sup>	
<b>Fresh water test cycles</b>											
F-1	23	0.36	48	7.8	7.3	66	213	182	108	93	1
F-2	22	0.33	48	8.5	7.2	65	209	179	101	90	1
F-3	16	0.37	59	6.5	7.6	56	311	222	128	118	5
F-4	16	0.36	55	6.6	6.8	62	282	213	120	108	1
F-5	17	0.36	56	7.1	7.8	52	272	187	122	111	5
<b>Brackish water test cycles</b>											
B-1	20	17	68	7.1	7.5	72	486	197	254	199	1
B-2	22	17	65	7.8	8.3	65	457	191	247	187	1
B-3 <sup>(5)</sup>	18	20	52	12	8.2	64	226	178	103	99	1
B-4	14	22	61	8.8	7.8	68	343	215	138	125	5
B-5	14	22	61	8.8	7.8	68	341	229	132	116	5
B-6 <sup>(5)</sup>	13	20	51	14	8.3	68	187	227	78	70	1
B-7	12	19	50	15	6.9	58	133	209	56	52	1
<b>Marine water test cycles</b>											
M-1	24	29	50	14	7.5	81	210	180	106	92	1
M-2	18	29	73	7.2	5.8	44	508	178	232	223	1
M-3	17	29	73	7.2	5.8	44	526	181	240	235	1
M-4	13	30	61	8.3	6.2	64	340	187	151	140	5
M-5	14	30	61	8.3	6.2	64	330	190	144	137	5

- (1) UVT measured during ballast operation.
- (2) UVI average value during ballasting operation.
- (3) UV dose average value during ballasting operation.
- (4) Flow rate is calculated (as processed volume by operation time) measured after filtration during ballasting operation.
- (5) Test cycles B-3 and B-6 were each determined to be invalid by DNV GL due to technical issues with the BWTS that prevented the system to deliver the target dose.



**Table 2** Average densities of live organisms in inlet and treated discharge water during land-based testing of the Hyde GUARDIAN-US BWTS, model HG300U with Filtrex ACB-945-200 filter (20 µm mesh size) and UV reactor (8 lamps at 6.0 kW) with TRC 300 m<sup>3</sup>/h. Live organisms ≥10 and <50 µm in discharge water were quantified based on CMFDA/FDA. All counts of pathogenic bacteria (*E. coli*, *Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard. Tests were performed in the period July to October 2018 at DHI in Denmark.

Test cycle	Organism densities in inlet water		Organisms densities in discharge water			
	≥50 µm (org/m <sup>3</sup> )	≥10-<50 µm (org/mL)	≥50 µm (org/m <sup>3</sup> )		≥10-<50 µm (org/mL)	
	inlet	inlet	treated	control	treated	control
<b>fresh water test cycles</b>						
F-1	1,185,134	2,108	0	528,022	7.6	2,388
F-2	1,794,978	1,801	1.5	712,876	7.8	1,490
F-3	488,056	1,132	0	352,607	0	629
F-4	361,056	1,492	0	226,483	8.2	1,235
F-5	697,556	1,230	2.7	360,426	1.0	664
<b>Brackish water test cycles</b>						
B-1	544,609	1,102	0.33	150,918	0.17	749
B-2	207,161	2,347	0	98,235	0.67	1,321
B-3 <sup>(1)</sup>	334,561	2,433	0.33	102,300	17.7	1,163
B-4	165,828	1,073	0.33	92,844	0.33	515
B-5	184,494	1,045	1.0	92,844	1.7	515
B-6 <sup>(1)</sup>	172,408	1,515	2.7	127,679	10.1	1,159
B-7	115,789	1,378	3.3	54,634	5.1	1,382
<b>Marine water test cycles</b>						
M-1	302,878	3,590	0	83,615	1.2	354
M-2	252,883	1,310	1.0	165,626	2.7	784
M-3	271,806	1,360	0	165,626	1.8	784
M-4	224,961	1,497	0.67	72,283	0	917
M-5	211,472	1,487	0	72,283	0.17	917

(1) Test cycles B-3 and B-6 were each determined to be invalid by DNV GL due to technical issues with the BWTS that prevented the system to deliver the target dose.

**Shipboard testing**

**Table 3** Results from shipboard testing of Hyde GUARDIAN-US BWTS, model HG750U with Filtrex ACB-985-300 filter (20 µm mesh size) and UV reactor (18 lamps at 7.7 kW) with TRC 750 m<sup>3</sup>/h, performed in the period November 2018 to October 2019 on board the vessel Bore Sea. Test conditions: salinity: 0.18-15 PSU, temp: 4.3-22°C. Live organisms ≥10 and <50 µm in discharge water were quantified based on FDA/CMFDA method. All counts of pathogenic bacteria (*E. coli*, *Enterococci* and *Vibrio cholerae*) in treated water were below the ballast water discharge standard.

Test cycle <sup>(1)</sup>	UVT (%)	Flow rate <sup>(2)</sup> (m <sup>3</sup> /h)	Holding time (hour:min)	UVI <sup>(3)</sup> (mW/cm <sup>2</sup> )	UV dose (mJ/cm <sup>2</sup> )	≥50 µm (org/m <sup>3</sup> )		≥10-<50 µm (org/mL)	
						inlet	discharge	inlet	discharge
SB-2	86	682	20:18	445	208	14,821	0.91	124	4.7
SB-4	72	611	20:47	821	436	10,180	7.5	755	2.0
SB-7	80	632	34:30	523	250	12,762	9.2	242	2.5
SB-9	83	633	24:49	532	268	9,882	2.0	212	0.33
SB-11	55	381	36:59	233	199	39,638	3.0	195	2.8

- (1) Test cycle SB-1 (successful) was performed in November 2018 but was declared invalid due to low phytoplankton counts. Test cycle SB-3 was abandoned due to low phytoplankton counts. Test cycles SB-5, SB-6, SB-8 and SB-10 were each determined invalid due to technical and procedural reasons, which are explained more in details in the INF report to IMO related to this type approval certificate.
- (2) Average flow rate after filtration during ballast operation of treated water, measured by the BWMS flow meter located after the filter; extracted from BWMS log.
- (3) UVI average value during ballasting operation.