DESMI - AQUASHIELD AND AQUADOSE DOSE EQUATIONS

Evaluation of AquaShield and AquaDose Dose Equations developed by DESMI Ocean Guard

DESMI Ocean Guard A/S

Report no.: 262.1-040945-J-7, Rev. 0
Document no.: 32925596/DNV
Date: 2024-02-16

Summary

DNV has on behalf of DESMI Ocean Guard (DESMI) performed an independent assessment of the proposed methodology for calculating UV dose for the DESMI AquaShield and AquaDose water treatment systems for use in aquaculture applications. The range of systems included in the assessment has previously been subject to DNV approval for use for ballast water treatment. DNV's assessment is based on documentation received from DESMI and includes no independent DNV testing or analysis. As such, the assessment is based on review of information received from DESMI to confirm sufficiency and adequacy for the specified application. It is acknowledged that the dose calculation method will form the basis for the UV reactor control for aquaculture applications.

The dose calculation methodology is for each model defined as function of water quality (UVT), flowrate and lamp power Delivered dose for each model as function of operating conditions is established based on computational fluid dynamic (CFD) modelling. The applied CFD model was validated in biodosimetry testing. The dose model is based on minimum dose delivered, hence independent of organism treated, and has previously been reviewed by DNV and confirmed adequate for estimation of delivered dose.

Based on review of documentation, assessment and DESMI reply to clarification comments, the methodology for dose calculation proposed by DESMI for the AquaShield and AquaDose water treatment systems for aquaculture application is considered applicable.

Project name:	DESMI - AquaShield and AquaDose Dose Equations	DNV AS Ship Classification
Report title:	Evaluation of AquaShield and AquaDose Dose Equations developed by DESMI Ocean Guard	Environmental Technologies Sea Veritasveien 1
Customer:	DESMI Ocean Guard A/S, Tagholm 1 9400 Nørresundby Denmark	1363 Høvik Norway
Customer contact:	Søren Buch	
Date of issue:	2024-02-16	
Project no.:	262.1-040945-1 / 10423833	
Organisation unit:	M-SA-ES	
Report no.:	262.1-040945-J-7, Rev. 0	
Document no.:	32925596/DNV	

Applicable contract(s) governing the provision of this Report:

SFA-A1468435 for the evaluation of the AquaShield and AquaDose Dose Equations by DESMI

Objective:

Evaluation by DNV of the AquaShield and AquaDose Dose Equations documentation by DESMI

Prepared by:	Verified by:	Approved by:
Lars Even Torbergsen Senior Principal Specialist Pipeline Operations Norway	Michael Lehmann Head of Section Environmental Technologies Sea	Digitally Signed By: Lehmann, Michael Location: DNV Høvik, Norway Michael Lehmann Head of Section Environmental Technologies Sea

Internally in DNV, the information in this document is classified as:

	Can the document be distributed internally within DNV after a specific date? No	Yes
☐ Open ☐ DNV Restricted	--	--
☒ DNV Confidential ☐ DNV Secret	☒	☐

Additional authorised personnel for distribution within DNV:

-

Keywords UV treatment, UV dose

Rev. no.	Date	Reason for issue	Prepared by	Verified by	Approved by
0	2024-02-16	First issue	LETOR	MLEH	MLEH

Table of contents

1 EXECUTIVE SUMMARY

DNV has on behalf of DESMI Ocean Guard (DESMI) performed an independent assessment of the proposed methodology for calculating UV dose for the DESMI AquaShield and AquaDose water treatment systems for use in aquaculture applications. The range of systems included in the assessment has previously been subject to DNV approval for use for ballast water treatment. DNV's assessment is based on documentation received from DESMI and includes no independent DNV testing or analysis. As such, the assessment is based on review of information received from DESMI to confirm sufficiency and adequacy for the specified application. It is acknowledged that the dose calculation method will form the basis for the UV reactor control for aquaculture applications.

The dose calculation methodology is for each model defined as function of water quality (UVT), flowrate and lamp power Delivered dose for each model as function of operating conditions is established based on computational fluid dynamic (CFD) modelling. The applied CFD model was validated in biodosimetry testing. The dose model is based on minimum dose delivered, hence independent of organism treated, and has previously been reviewed by DNV and confirmed adequate for estimation of delivered dose.

Based on review of documentation, assessment and DESMI reply to clarification comments, the methodology for dose calculation proposed by DESMI for the AquaShield and AquaDose water treatment systems for aquaculture application is considered applicable.

2 INTRODUCTION

2.1 Background

DESMI Ocean Guard (DESMI) has approached DNV to perform an independent assessment of the for Aquaculture application. The treatment system is based on pre-filtration and subsequent treatment with UV radiation in a UV reactor. The UV reactor applies medium pressure (MP) lamps. The range of systems included in the assessment has previously been subject to DNV approval for use for ballast water treatment.

The assessment is based on documentation received from DESMI and includes no independent DNV testing or analysis. As such, the assessment is based on review of information received from DESMI to confirm sufficiency and adequacy for the specified application. It is acknowledged that the dose calculation method will form the basis for the UV reactor control for aquaculture applications.

2.2 Objective

The objective of this technical memo is to summarize an independent DNV assessment concerning the dose calculation methodology proposed by DESMI for the AquaShield and AquaDose water treatment systems for aquaculture application.

2.3 Scope and limitations

Scope of this document cover:

- Assessment of dose calculation model

2.4 Abbreviations

CFD	computational fluid dynamics
DHI	Danish Hydraulic Institute
MP	medium pressure
NVI	Norwegian Veterinary Institute
UV	ultra-violet
UVT	UV transmittance

3 TECHNLOGY DESCRIPTION

The configuration of the AquaShield and AquaDose water treatment systems include pre-filtration with mesh size less than 100 µm /1/ followed by a medium pressure lamp (MP) UV reactor. The UV dose simulations are based on the dose delivered in the UV-C range 200-280 nm as function of water quality, flowrate and UV reactor operation. The dose calculation methodology is for each model defined as function of water quality (UVT), flowrate and lamp power. The dose calculation model is for each model established based on computational fluid dynamic (CFD) modelling. The dose model is based on minimum dose delivered, hence independent of organism treated and has previously been reviewed by DNV and confirmed adequate for estimation of delivered dose.

4 DOSE CONTROL

4.1 General

Dose model is validated by comparing CFD with testing for MS2 /1/ for combinations of UVT and flowrate. Results compare within 8.5% /1/. It is assumed linear relationship between flow and Dose (implicitly minimum dose) /1/. Independent verification of the UV dose calculation method as function of UV reactor geometry, lamp configuration and operation, sensor water layer, water UVT and flowrate is performed by DHI, confirming adequacy and accuracy of the model.

In response to DNV comments, additional information provided in /3/ is included in the current assessment (see Appendix A).

4.2 Dose calculation model

UV dose may be expressed in different terms, either based on the dose distribution curve or reduction equivalent dose (RED). For the current assessment dose value shall be interpreted as the minimum dose received by any particle passing the UV reactor /2/:

> *Minimum Dose means the amount of UV-C light (254nm) absorbed by the particle passing through the UV-Unit receiving the absolute least, thus meaning all other particles will receive more. This dose is based on extensive CFD simulations and verified through 3rd party bio-dosimetry testing, which has been evaluated by numerous accreditation bodies.

The dose calculation model is formulated and initially proposed applicable for the range in minimum dose from 25 to 500 mJ/cm^2. The applicable range in dose was eventually adjusted to 25-300 mJ/cm^2 (see Appendix A). Depending on organism to be treated (dose sensitivity), the reduction equivalent dose (RED) is foreseen to be higher than the calculated minimum dose. E.g. for MS-2, the RED is estimated to be approximately a factor two (2) higher than the minimum dose /1/. Implicitly, controlling the maximum flowrate for a given reactor and UVT based on minimum dose is generally considered conservative.

4.3 General comments to referenced documents

DNV comments to /1/ and reply from DESMI is included in Appendix A. Reply to all comments accepted and comments closed. The reply to comment are included in basis for the assessment in 4.4.

4.4 Assessment

The assessment applies generally to the following DESMI reactor sizes:

AquaShield Units	AquaDose Units
V10024 SS14410	AD20024
V15044 SS14410	AD25044
V15064 SS14410	AD30064
V20066 SS14410	AD40066
V20086 SS14410	AD50086
V25126 SS14410	AD50126
V30186 SS14410	AD70186
V35246 SS14410	AD70612
V40366 SS14410	AD70912
	AD80912
	AD11212
	AD11812

Validation /1/ of the CFD model dose model though biodosimetry testing is performed in the range of RED [108, 128] mJ/cm^2 and minimum dose [59.7, 64.9] mJ/cm^2. For treatment of ballast water, it is understood that the target minimum dose is approx. 60 mJ/cm^2, hence close to validation point. For aquaculture application, the dose scaling model is proposed applicable for the range of minimum dose [25, 300] mJ/cm^2 /3/, hence outside the range of model validation.

It is acknowledged that the CFD model should be capable of representing the physics of both light intensify and flow field. Considering that the geometrical configuration of the reactor, including lamp configuration remains unchanged, it is considered reasonable to conclude that the dose predictions will be sufficiently accurate for the expanded range of target dose.

The dose control curve is based on curve fit to the CFD dose simulations. Hence, on the condition that the dose simulations provide a sufficiently accurate prediction, the dose control curve would also provide a sufficiently accurate prediction and control.

5 CONCLUSIONS

Based on review of documentation, assessment and DESMI reply to DNV comments, the methodology for dose calculation proposed by DESMI for the AquaShield and AquaDose water treatment systems for aquaculture application is considered applicable.

6 REFERENCES

/1/ DESMI Ocean Guard application for NVI type approval

/2/ UV – Aquadose 50086 datasheet

/3/ DESMI Ocean Guard application for DNV assessment_R02 - Updated

APPENDIX A
DNV comments and DESMI reply

General comments to /1/, including reply from DESMI and DNV final conclusion, is included in table below.

DNV comment	DESMI reply	DNV conclusion
1. Please check document with regards to completeness and consistency with regards to units. E.g. UVT is given both as fraction and percentage (%). Even though obvious to most readers, Eq. (5) applies UVT fraction (0-1).	We use UVT Fraction (0 1) throughout the whole set of equation s. It is correct that we in some graphs and tables display the UVT value as percentage (%), but I would argue that 55% still equal s 0,55 in numerical value.	Comment closed
2. Validation /1/ of the CFD model is performed in the range of RED [108, 128] mJ/cm^2 & minimum dose [59.7, 64.9] mJ/cm^2. For treatment of ballast water, it is understood that target minimum dose is approx. 60 mJ/cm^2, hence close to validation point. For aquaculture application, the dose scaling model is proposed applicable for the range of minimum dose [25, 500] mJ/cm^2, hence significantly outside the range of model validation. It is acknowledged that the CFD model should be capable of representing the physics of both light intensify and flow field. Still, please confirm whether additional validation (or testing) is planned for the wider range in dose.	We acknowledge that the dose ranging up to 500 mJ/cm² is excessive. From operational experience in fish farms, we need to supply a verified dose range of 25-300 mJ/cm². We have created a new document DESMI Ocean Guard application for DNV assessment_R02-Updated .pdf. In this document we have updated the scope to 25-300 mJ/cm². More tests will be conducted at DHI in Hundested Denmark, as part of the NVI verification process. The test will include 12 week continues disinfection of sea water , with samples taken weekly . Please note that this is not a biocosmetic test. But we will be able to see the UV's performance over a wide dose range.	Comment closed based, acknowledging reduction in maximum dose to 300mJ/cm^2
3. For the lower dose range (down to 25 mJ/cm^2) combined with high UVT, it is understood that a significantly higher flowrate than for BWT application will be allowed for. The higher pressure loss /2/ through the reactor is acknowledged. It should be confirmed that the drag force and potential vortex induced loading on the lamp sleeve is still acceptable for the higher flowrates.	The combination of 25mJ/cm² and very high UVT values for the AquaShield is more of a theoretical scenario produced by extremities of the equation Pressure drop would prevent a customer from this type of configuration The tables are merely a visual representation of the equation. For the AquaDose units the pressure drop is significantly lower, and the 25mJ/cm² + very high UVT is therefore a viable scenario. In this instance you are asking if the drag force and potential vortex induced loading on the lamp sleeve is still acceptable for the higher flowrates. We know that competing brands , with similar UV lamps and quartz already have installations in operation under these conditions. We use 2 mm thick synthetic quartz, which is above industry standard in thickness, and we see no issues in using our quartz in these high velocity scenarios. UV units will be specified with a max flowrate for physical safety reasons. New max flowrate capacity has also been updated in the document: DESMI Ocean Guard application for DNV assessment_R02 Updated .pdf	Comment closed based on reply
4. Please confirm for the range of flowrate allowed for each model, that the filtration area will be increased to match the flux applied for BWT application (m/s).	Yes, the filter area will increase to match the flow. So different filter sizes for different max flowrates.	Comment closed based on reply

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.