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Report

Clipper Harald HFO operation with scrubber

Wash water analysis at berth in Stenungsund and Kårstø

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Report

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ABSTRACT

To investigate the environmental risk by operating an open loop exhaust gas cleaning system (EGC) with wash water cleaning system, wash water samples have been taken of the inlet seawater, after scrubber, wash water overboard. Sample tests has been collected at port in Stenungsund and Kårstø when auxiliary engines operating on HFO. The EGC was operated in two different modes.

IMO Marpol regulation
US EPA VGP regulation

The conclusion of this investigation is that an open loop exhaust gas scrubbing system with wash water cleaning system will emit a reasonable low level of environmental risk factor, PEC/PNEC, with the wash water emitted to the seawater. The wash water will under all operation modes obtain the same level of environmental risk factor, PEC/PNEC as the surrounding seawater at a distance of maximum 8,5 m from point of discharge.

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1 Summary and conclusion

To investigate the environmental risk by operating an open loop exhaust gas cleaning system (EGC) with wash water cleaning system, wash water samples have been taken of the inlet seawater, after scrubber, wash water overboard. Sample tests has been collected at port in Stenungsund and Kårstø when auxiliary engines operating on HFO. The EGC was operated in two different modes.

IMO Marpol regulation
US EPA VGP regulation

The initial PEC/PNEC analysing from Stenungsund, see appendix A, showed abnormal environmental risk factors due to high concentration of Copper and Zinc. The samples taken at Stenungsund proved to be contaminated by the sampling system from brass valve and fittings and copper pipes. New sampling procedure using stainless steel and plastic pipes were established and used on the samples collected Kårstø

Sum of environmental risk factors (PEC/PNEC) for seawater inlet gave a value range of 8 to11 at Steungsund and a value range of 5 to 7 at Kårstø. This indicate a conservative concentration limits in the OSPAR regulation (Oslo PARis convention 2012) when the Kårstø waters reach a level of 5-7 and a factor between 1-10 is of concern if supply volumes increase.

Sum of emission factors (PEC/PNEC) for net overboard (wash water overboard – seawater inlet):

- Stenungsund IMO Marpool regulation (without reaction water): 58
- Stenungsund US EPA VGP regulation (added reaction water): 15
- Kårstø IMO Marpool regulation (without reaction water): 45
- Kårstø US EPA VGP regulation (added reaction water): 14

The main driving component for sum of environmental risk factors is vanadium that is highly soluble in water.

Stenungsund
With IMO operation, test 1, the wash water will recover to the same PEC/PNEC ratio as the inlet water when obtain a concentration 11/63 i.e. ~18% of the concentration at point of discharge.

With US EPA VGP operation, test 3, the PEC/PNEC ratio will recover to the same value as the inlet water when obtain a concentration 8/23 i.e. ~35% of the concentration at point of discharge.

Kårstø.
With IMO operation, test 1, the PEC/PNEC ratio will recover to the same level as the inlet value when obtain a concentration 7/50 i.e. ~14% of the concentration at point of discharge.

With US EPA VGP operation the PEC/PNEC ratio will recover to the same value as the inlet water when obtain a concentration 5/19 i.e. ~26% of the concentration at point of discharge.

The environmental risk factor PEC/PNEC ratio will obtain the same level as the surrounding seawater with reference to the two operation modes, see modelling in chapter 5:

- IMO operation: between ~6-7 meter from the point of discharge.
- US EPA operation: between ~3,5 - 5 meter from the point of discharge.

The affected radius is less than 0,5 meter.

For additional evaluation of the chemical components in the wash water samples, condition classification of costal seawater from Norwegian Environmental Agency, are used as the value "Class II Good" and "Class IV Poor". Using this classification the inlet seawater at Kårstø and Stenungsund (eliminating the contaminated components copper and zinc) are classified as good, see tables in chapter 3.

Wash water quality after cleaning system is in general in the range of good with some component above good, marked moderate, and well below quality poor.

Vanadium and nickel are marked high but still below quality poor.

Water cleaning system is crucial to obtain good quality of the wash water. The wash water cleaning system is based on gravity and will reduce components which is heavier or lighter than seawater, i.e. metals, oil and soot. The cleaning system is reducing all components except from Nickel and Vanadium. As an example PEC/PNEC on test 1 at Kårstø, 95 after scrubber reduced to 50 after cleaning system, a reduction of 48%.

The conclusion of this investigation is that an open loop exhaust gas scrubbing system with wash water cleaning system will emit a reasonable low level of environmental risk factor, PEC/PNEC, with the wash water emitted to the seawater. The wash water will under all operation modes obtain the same level of environmental risk factor, PEC/PNEC as the surrounding seawater at a distance of maximum 8,5 m from point of discharge.

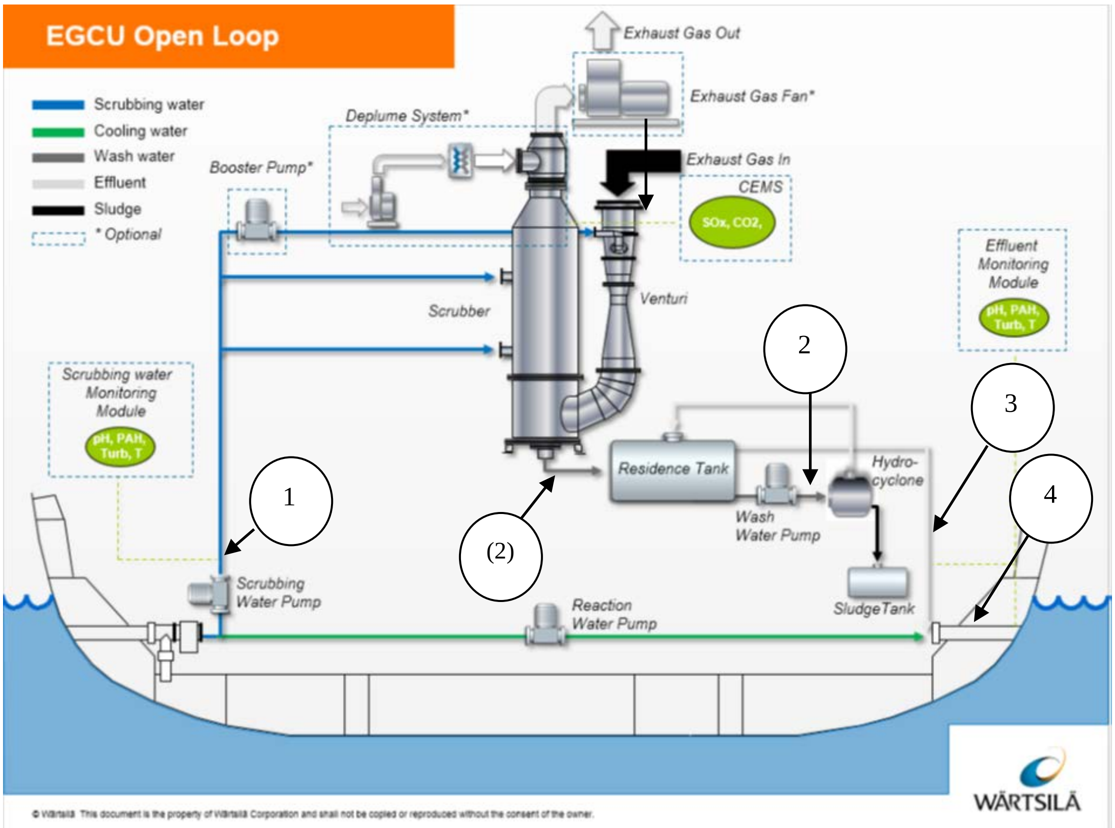
2 Introduction

Clipper Harald, a LPG carrier operating between Kårstø and Rafnes or Stenungsund in Sweden. Operating on HFO both main engine and auxiliary engines, employing exhaust gas scrubbers on main engine and axillary engines, to meet sulphur emission limitation of 0,1%. The ship is additionally using Exhaust Gas Recirculation (EGR) to control NOx emission.

Exhaust gas scrubbing in combination with EGR is a part of the research program Smart Maritime where Solvang and Wärsilä are among 18 industrial partners (www.smartmaritime.no). This report is evaluating the wash water quality emitted from the ship at berth in Stenungsund and Kårstø, operating auxiliary engines on HFO.

3 Wash water sampling and analysis

Clipper Harald is equipped with Wärtsilä open loop scrubber system including wash water treatment. A principle layout of the scrubber system and sampling points are shown in the figure below. Sampling was done by the ship crew and sent to ALS Laboratory Group Norway AS for chemical analyses.



Principle layout of the scrubber system with wash water treatment
Sampling point 1: Inlet seawater supply to scrubber
Sampling point 2: After scrubber before hydro cyclone (Stenungsund)
Sampling point (2): After scrubber (Kårstø)
Sampling point 3: Wash water overboard (without reaction water)
Sampling point 4: Wash water over board (added reaction water)

Two different type of samples:

1. IMO Marpol regulations; pH > 6,5 four meter from point of discharge (no reaction water)
2. US EPA VGP regulations; pH > 6,0 at point of discharge (US Environmental Protection Agency -- Vessel General Permit) (added reaction water)

The Exhaust Gas Cleaning System is certified after Marpol regulation, which means that the wash water overboard shall be within the following limits:

IMO Marpol regulations pH >6,5 four meter from point of discharge

Overboard;

PAH (Delta µg/l)	50
Turbidity (Delta FNUs)	25
Nitrates (mg/l)	60

The above-mentioned parameters are continuously measured so that compliance can be demonstrated to all interested parties.

The US EPA VGP operation require pH > 6,0 overboard, this can be achieved by increasing the amount of water to the discharge, the alkanity in the reaction water will neutralize the sulphure acid created by the sulpure in the fuel and by this increase the pH. The limits for PAH, Turbidity and Nitrates are the same as above and must be measured before any addition of reaction water

Samples for evaluation:

- N1612491 test 1 Stenungsund IMO operation pH > 6,5 (four meter from point of discharge)
- N1612493 test 3 Stenungsund US EPA VGP Regulation (pH > 6,0 overboard) added reaction water
- N1616941 test 1 Kårstø IMO operation pH > 6,5 (four meter from point of discharge)
- N1616942 test 2 Kårstø US EPA VGP Regulation (pH > 6,0 overboard) added reaction water

The four samples are evaluated for potential environmental effects by SINTEF and presented in a separate report attached to this report (Appendix A SINTEF F27953 Environmental risk characterization of wash water emitted from ship using EGR and scrubber technology)

Test 1 and test 3 Stenungsund are consider representative for the four samples taken in Stenungsund. The remaining two additional samples from Stenungsund test 2 (repeating test 1) and test 4 (repeating test 3) are shown in this report as well for information.

For additional evaluation of the chemical components in the samples, condition classification of costal seawater from Norwegian Environmental Agency, are shown by listing the value "Class II Good" and "Class IV Poor". The Norwegian Environmental Agency document M-608 "Grenseverdier for klassifisering av vann, sediment og biota", appendix B

I Bakgrunn	II God	III Moderat	IV Dårlig	V Svært dårlig
Bakgrunnsnivå	Ingen toksiske effekter	Kroniske effekter ved langtids-eksponering	Akutt toksiske effekter ved kort-tidseksponering	Omfattende toksiske effekter
Øvre grense: bakgrunn	Øvre grense: AA-QS, PNEC	Øvre grense: MAC-QS, $PNEC_{akutt}$	Øvre grense: $PNEC_{akutt}$* AF[1)]	

Figur: Klassifiseringssystem for vann og sediment. 1) AF: sikkerhetsfaktor

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3.1 Stenungsund samples

Test 1 Stenungsund (IMO operation pH > 6,5 four meter from point of discharge)

From: ALS Laboratory Group Norway AS, Drammensveien 173, N-0277 Oslo. Tlf. +47 2213 1800. Faks. +47 2252 5177. Email: info.on@alsglobal.com							
To: Solvang ASA Ref: Halvard Benjaminsen [solvang.ethylene@solvangship.no;hbe@solvangship.no]							
Program: WATER-EN							
Ordernumber: N1612491 (PO nr: 2016-0231; Sample at Stenungsund)							
Report created: 2016-09-07 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		Supply Sea Water Test 1	After Scrubber Test 1	Water Overboard Test 1	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	<5.0	<5.0			
Fraksjon >C12-C16	µg/l	<5.0	6	7,6			
Fraksjon >C16-C35	µg/l	<30	197	148			
Fraksjon >C35-C40	µg/l	<10	17	12			
Fraksjon >C10-C40	µg/l	<50	221	171			
Sum >C12-C35	µg/l	n.d.	203	156			
Naftalen	µg/l	<0.030	4,19	3,86	2	650	Moderate
Acenaftylen	µg/l	<0.010	<0.010	<0.010	1,3	330	
Acenaften	µg/l	<0.010	0,12	0,107	3,8	382	
Fluoren	µg/l	<0.010	0,342	0,322	1,5	339	
Fenantren	µg/l	<0.020	0,762	0,67	0,51	67	Moderate
Antracen	µg/l	<0.010	<0.010	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,074	0,066	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,072	0,064	0,023	0,23	Moderate
Benso(a)antracen^	µg/l	<0.010	<0.010	<0.010	0,012	1,8	
Krysen^	µg/l	<0.010	<0.010	<0.010	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	<0.010	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	5,6	5,1			
Sum PAH carcinogene^	µg/l	n.d.	n.d.	n.d.			
Nitrat (NO3)	mg/l	<2.50	<2.50	<2.00			
Nitritt (NO2)	mg/l	<0.0329	<0.0329	<0.0329			
Turbiditet	FNU	0,96	6,25	5,88			
pH		8,12	2,75	2,73			
As (Arsen)	µg/l	5,85	5,77	2,47	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	<0.05	<0.05	0,2	4,5-15 *	Moderate
Co (Kobolt)	µg/l	<0.2	<0.2	0,21	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	1,32	1,91	3,4	358	
Cu (Kopper)	µg/l	14,8	1240	2490	2,6	5,2	High
Mo (Molybden)	µg/l	8,63	8,77	9,07	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	0,656	51,4	57,7	8,6	67	High
Pb (Bly)	µg/l	3,71	86,7	0,553	1,3	57	Moderate
V (Vanadium)	µg/l	0,989	218	214	6 (1)	600 (1)	High
Zn (Sink)	µg/l	122	714	330	3,4	60	High
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

Test 2 Stenungsund (IMO operation pH > 6,5 (IMO operation pH > 6,5 four meter from point of discharge)

From: ALS Laboratory Group Norway AS, Drammensveien 173, N-0277 Oslo. Tlf. +47 2213 1800. Faks. +47 2252 5177. Email: info.on@alsg							
To: Solvang ASA Ref: Halvard Benjaminsen [solvang.ethylene@solvangship.no;hbe@solvangship.no]							
Program: WATER-EN							
Ordernumber: N1612490 (PO nr: 2016R-0231; Sample at Stenungsund)							
Report created: 2016-09-07 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		SW inlet Test 2	After Scrubber Test 2	SW Overboard Test 2	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	<5.0	<10.0			
Fraksjon >C12-C16	µg/l	<5.0	7,6	17,1			
Fraksjon >C16-C35	µg/l	<30	252	463			
Fraksjon >C35-C40	µg/l	<10	21	38			
Fraksjon >C10-C40	µg/l	<50	282	524			
Sum >C12-C35	µg/l	n.d.	260	480			
Naftalen	µg/l	<0.030	4,16	4,02	2	650	Moderate
Acenaftylen	µg/l	<0.010	<0.010	<0.010	1,3	330	
Acenaften	µg/l	<0.010	0,118	0,118	3,8	382	
Fluoren	µg/l	<0.010	0,35	0,348	1,5	339	
Fenantren	µg/l	<0.020	0,774	0,73	0,51	67	Moderate
Antracen	µg/l	<0.010	<0.010	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,078	0,068	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,077	0,07	0,023	0,23	Moderate
Benso(a)antracen^	µg/l	<0.010	0,01	0,011	0,012	1,8	
Krysen^	µg/l	<0.010	<0.010	0,011	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	<0.010	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	5,6	5,4			
Sum PAH carcinogene^	µg/l	n.d.	0,01	0,022			
Nitrat (NO3)	mg/l	<2.50	<2.50	<2.50			
Nitritt (NO2)	mg/l	<0.0329	<0.0329	<0.0329			
Turbiditet	FNU	1,4	5,81	6,71			
pH		8,12	2,74	2,72			
As (Arsen)	µg/l	3,04	5,73	2,9	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	<0.05	<0.05	0,2	4,5-15 *	
Co (Kobolt)	µg/l	<0.2	<0.2	0,297	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	<0.9	2,1	3,4	358	
Cu (Kopper)	µg/l	13,8	1230	3590	2,6	5,2	High
Mo (Molybden)	µg/l	7,61	8,98	8,42	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	0,619	44,9	54,4	8,6	67	Moderate
Pb (Bly)	µg/l	2,21	82,6	1,83	1,3	57	Moderate
V (Vanadium)	µg/l	1,71	206	187	6 (1)	600 (1)	High
Zn (Sink)	µg/l	136	233	758	3,4	60	High
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

3.2 Comments to Stenungsund test 1 and test 2

Condition classification of costal seawater from Norwegian Environmental Agency, are shown by listing the value "Class II Good" and "Class IV Poor", see appendix B.

The components marked moderate have a concentration that is higher than the value for good, but well below the value for poor quality.

The level of Arsen is higher than quality good in the inlet water and varies between 3,04 and 5,85 in the inlet water. Nickel is marked high.

Values for copper and zinc are abnormal high level and marked high. Vanadium is also considered high level.

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Test 3 Stenungsund (US EPA VDGP operation pH > 6,0 at point of discharge) added reaction water

From: ALS Laboratory Group Norway AS, Drammensveien 173, N-0277 Oslo. Tlf. +47 2213 1800. Faks. +47 2252 5177. Email: info.on@alsglobal.com							
To: Solvang ASA Ref: Halvard Benjaminsen [solvang.ethylene@solvangship.no;hbe@solvangship.no]							
Program: WATER-EN							
Ordernumber: N1612493 (PO nr: 2016-0231; Sample at Stenungsund)							
Report created: 2016-09-07 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		Supply Sea Water Test 3	After Scrubber Test 3	Water Overboard Test 3	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	6,8	<5.0			
Fraksjon >C12-C16	µg/l	<5.0	17,5	<5.0			
Fraksjon >C16-C35	µg/l	<30	396	67			
Fraksjon >C35-C40	µg/l	<10	32	<10			
Fraksjon >C10-C40	µg/l	<50	452	78			
Sum >C12-C35	µg/l	n.d.	414	67			
Naftalen	µg/l	<0.030	4,1	0,136	2	650	
Acenaftylen	µg/l	<0.010	<0.010	0,018	1,3	330	
Acenaften	µg/l	<0.010	0,1	0,03	3,8	382	
Fluoren	µg/l	<0.010	0,326	0,115	1,5	339	
Fenantren	µg/l	<0.020	0,769	0,255	0,51	67	
Antracen	µg/l	<0.010	<0.010	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,103	0,023	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,107	0,022	0,023	0,23	
Benso(a)antracen^	µg/l	<0.010	0,012	<0.010	0,012	1,8	
Krysen^	µg/l	<0.010	0,017	<0.010	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	<0.010	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	5,5	0,6			
Sum PAH carcinogene^	µg/l	n.d.	0,029	n.d.			
Nitrat (NO3)	mg/l	<2.50	<2.50	<5.00			
Nitritt (NO2)	mg/l	<0.0329	<0.0329	0,0201			
Turbiditet	FNU	0,98	7,72	3,38			
pH		8,13	2,79	6,22			
As (Arsen)	µg/l	4,09	4,09	5,21	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	0,0785	<0.05	0,2	4,5-15 *	
Co (Kobolt)	µg/l	<0.2	0,206	<0.2	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	1,43	<0.9	3,4	358	
Cu (Kopper)	µg/l	38,2	568	191	2,6	5,2	High
Mo (Molybden)	µg/l	8,44	8,35	8,94	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	0,985	48	12,4	8,6	67	Moderate
Pb (Bly)	µg/l	1,49	93,9	<0.5	1,3	57	Moderate
V (Vanadium)	µg/l	1,47	227	50,2	6 (1)	600 (1)	Moderate
Zn (Sink)	µg/l	116	147	137	3,4	60	High
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

Test 4 Stenungsund (US EPA VDGP operation pH > 6,0 at point of discharge) added reaction water

From: ALS Laboratory Group Norway AS, Drammensveien 173, N-0277 Oslo. Tlf. +47 2213 1800. Faks. +47 2252 5177. Email: info.on@a							
To: Solvang ASA Ref: Halvard Benjaminsen [cheng.clipper.harald@solvangship.no;master.clipper.harald@solvangship.no;solvang.ethyle							
Program: WATER-EN							
Ordernumber: N1612492 (PO nr: 2016-0231; Sample at Stenungsund)							
Report created: 2016-09-07 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		SW inlet Test 4	After Scrubber Test 4	SW Overboard Test 4	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	5,3	<5.0			
Fraksjon >C12-C16	µg/l	<5.0	14,8	<5.0			
Fraksjon >C16-C35	µg/l	<30	351	41			
Fraksjon >C35-C40	µg/l	<10	27	<10			
Fraksjon >C10-C40	µg/l	<50	398	<50			
Sum >C12-C35	µg/l	n.d.	366	41			
Naftalen	µg/l	<0.030	4,13	1,07	2	650	
Acenaftylen	µg/l	<0.010	0,013	0,02	1,3	330	
Acenaften	µg/l	<0.010	0,097	0,035	3,8	382	
Fluoren	µg/l	<0.010	0,361	0,118	1,5	339	
Fenantren	µg/l	<0.020	0,822	0,272	0,51	67	
Antracen	µg/l	<0.010	<0.010	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,082	0,024	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,075	0,022	0,023	0,23	
Benso(a)antracen^	µg/l	<0.010	0,01	<0.010	0,012	1,8	
Krysen^	µg/l	<0.010	<0.010	<0.010	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	<0.010	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	5,6	1,6			
Sum PAH carcinogene^	µg/l	n.d.	0,01	n.d.			
Nitrat (NO3)	mg/l	<2.50	8,44	<2.50			
Nitritt (NO2)	mg/l	<0.0329	<0.0050	<0.0658			
Turbiditet	FNU	1,17	6,07	2,67			
pH		8,1	2,88	6,24			
As (Arsen)	µg/l	4,72	5,87	6,24	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	<0.05	<0.05	0,2	4,5-15 *	
Co (Kobolt)	µg/l	<0.2	<0.2	<0.2	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	<0.9	<0.9	3,4	358	
Cu (Kopper)	µg/l	15,7	148	184	2,6	5,2	High
Mo (Molybden)	µg/l	8,55	8,87	8,66	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	0,728	44,4	13	8,6	67	Moderate
Pb (Bly)	µg/l	1,35	51,2	<0.5	1,3	57	
V (Vanadium)	µg/l	1,53	195	53	6 (1)	600 (1)	Moderate
Zn (Sink)	µg/l	119	70,5	84,6	3,4	60	High
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

3.3 Comments to Stenungsund test 3 and test 4

Condition classification of costal seawater from Norwegian Environmental Agency, are shown by listing the value "Class II Good" and "Class IV Poor", see appendix B.

These tests are added reaction water (inlet seawater) before pumped overboard. Components marked moderate have a concentration higher than good quality but well below poor quality.

As for test 1 and test 2, concentration of copper and zinc are abnormally high and are the only values marked high.

Results from all four tests at Stenungsund show abnormally high concentration of copper and zinc and to some extent lead. A large variation of these values is noted in repeated samples.

From SINTEF report (Appendix A) we find that Cu and Zn are some of the main drivers for the elevated environmental risk factor (PEC/PNEC). This raised question of where do these components originates. Looking at HFO analysis, see appendix C, the fuel could not be the source for Cu or Pb, as there are no traces of those components in the fuel.

The high concentration of vanadium obviously comes from the HFO burned.

The suspicion was contamination of samples through the sampling valves and pipes, which are made of brass and copper. The main components in brass alloy are copper and zinc, among other components are lead.

New sampling connections and pipes of stainless steel and plastic material were installed and sampling point 2 was moved to directly after scrubber. A new set of tests was performed at Kårstø harbour.

3.4 Kårstø samples

Test 1 Kårstø (IMO operation pH > 6,5 (four meter from point of discharge)

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To: Solvang ASA Ref: Halvard Benjaminsen [cheng.clipper.harald@solvangship.no;solvang.ethylrnr@solvangship.no;master.clipper.harald							
Program: WATER-EN							
Ordernumber: N1616941 (PO nr:; Sampling off Kårstø)							
Report created: 2016-11-08 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		SW Inlet Test 1	After scrubber Test 1	Water overboard Test 1	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	<5.0	<5.0			
Fraksjon >C12-C16	µg/l	<5.0	17,8	9,3			
Fraksjon >C16-C35	µg/l	<30	506	270			
Fraksjon >C35-C40	µg/l	<10	46	22			
Fraksjon >C10-C40	µg/l	<50	569	302			
Sum >C12-C35	µg/l	n.d.	524	279			
Naftalen	µg/l	<0.030	1,99	1,85	2	650	
Acenaftylen	µg/l	<0.010	0,027	0,026	1,3	330	
Acenaften	µg/l	<0.010	0,126	0,115	3,8	382	
Fluoren	µg/l	<0.010	0,367	0,319	1,5	339	
Fenantren	µg/l	<0.020	1,19	0,998	0,51	67	Moderate
Antracen	µg/l	<0.010	<0.010	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,125	0,065	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,101	0,046	0,023	0,23	Moderate
Benso(a)antracen^	µg/l	<0.010	0,016	<0.010	0,012	1,8	
Krysen^	µg/l	<0.010	0,012	<0.010	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	0,021	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	0,012	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	4	3,4			
Sum PAH carcinogene^	µg/l	n.d.	0,049	n.d.			
Nitrat (NO3)	mg/l	<10.0	<10.0	<10.0			
Nitritt (NO2)	mg/l	0,0162	<0.0329	<0.0329			
Turbiditet	FNU	1,1	2,22	1,75			
pH		7,98	3,17	3,24			
As (Arsen)	µg/l	1,75	1,78	1,61	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	<0.05	<0.05	0,2	4,5-15 *	
Co (Kobolt)	µg/l	<0.2	<0.2	<0.2	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	1,87	<0.9	3,4	358	
Cu (Kopper)	µg/l	4,32	1,57	1,05	2,6	5,2	
Mo (Molybden)	µg/l	11,1	11,7	10,5	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	0,917	46,4	41,7	8,6	67	Moderate
Pb (Bly)	µg/l	0,759	0,527	<0.5	1,3	57	
V (Vanadium)	µg/l	1,27	168	164	6 (1)	600 (1)	High
Zn (Sink)	µg/l	<4	11	10,8	3,4	60	Moderate
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

Test 2 Kårstø (US EPA VGP Regulation (pH > 6,0 at point of discharge) reaction water added

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Program: WATER-EN							
Ordernumber: N1616942 (PO nr:; Sampling off Kårstø)							
Report created: 2016-11-08 by erlend.andresen					Norwegian Environment Agency		
ELEMENT	SAMPLE	Harbour mode:	Harbour mode:	Harbour mode:			
		SW Inlet Test 2	After scrubber Test 2	SW overboard Test 2	Class II Good	Class IV Poor	
Fraksjon >C10-C12	µg/l	<5.0	<5.0	<5.0			
Fraksjon >C12-C16	µg/l	<5.0	24	<5.0			
Fraksjon >C16-C35	µg/l	<30	384	83			
Fraksjon >C35-C40	µg/l	<10	38	<10			
Fraksjon >C10-C40	µg/l	<50	448	91			
Sum >C12-C35	µg/l	n.d.	408	83			
Naftalen	µg/l	<0.030	1,64	0,407	2	650	
Acenaftylen	µg/l	<0.010	0,029	0,032	1,3	330	
Acenaften	µg/l	<0.010	0,093	0,031	3,8	382	
Fluoren	µg/l	<0.010	0,291	0,078	1,5	339	
Fenantren	µg/l	<0.020	1,03	0,275	0,51	67	
Antracen	µg/l	<0.010	0,014	<0.010	0,1	1	
Fluoranten	µg/l	<0.010	0,075	0,018	0,0063	0,6	Moderate
Pyren	µg/l	<0.010	0,09	0,031	0,023	0,23	Moderate
Benso(a)antracen^	µg/l	<0.010	0,017	<0.010	0,012	1,8	
Krysen^	µg/l	<0.010	0,023	<0.010	0,07	0,7	
Benso(b)fluoranten^	µg/l	<0.010	0,013	<0.010	0,017	1,28	
Benso(k)fluoranten^	µg/l	<0.010	<0.010	<0.010	0,017	0,093	
Benso(a)pyren^	µg/l	<0.010	<0.010	<0.010	0,00017	1,5	
Dibenso(ah)antracen^	µg/l	<0.010	<0.010	<0.010	0,0006	0,14	
Benso(ghi)perylen	µg/l	<0.010	<0.010	<0.010	0,00082	0,14	
Indeno(123cd)pyren^	µg/l	<0.010	<0.010	<0.010	0,0027	0,1	
Sum PAH-16	µg/l	n.d.	3,3	0,87			
Sum PAH carcinogene^	µg/l	n.d.	0,053	n.d.			
Nitrat (NO3)	mg/l	<10.0	<10.0	<10.0			
Nitritt (NO2)	mg/l	<0.0329	<0.0329	<0.0329			
Turbiditet	FNU	0,48	2,53	0,87			
pH		7,99	3,29	6,52			
As (Arsen)	µg/l	1,7	1,58	1,59	0.6	85	Moderate
Cd (Kadmium)	µg/l	<0.05	<0.05	<0.05	0,2	4,5-15 *	
Co (Kobolt)	µg/l	<0.2	<0.2	<0.2	24,5 (1)	2450 (1)	
Cr (Krom)	µg/l	<0.9	1,51	<0.9	3,4	358	
Cu (Kopper)	µg/l	1,47	1,1	1,23	2,6	5,2	
Mo (Molybden)	µg/l	10,9	11,3	10,7	7,3 (1)	730 (1)	
Ni (Nikkel)	µg/l	1,7	46,1	11,2	8,6	67	Moderate
Pb (Bly)	µg/l	<0.5	<0.5	<0.5	1,3	57	
V (Vanadium)	µg/l	1,63	175	41,6	6 (1)	600 (1)	Moderate
Zn (Sink)	µg/l	<4	11,5	10,3	3,4	60	Moderate
Homogenisering		ja	ja	ja			
Marked (1) LC50 data from ECOTOX, safety factor of 100							

3.5 Comments to Kårstø test 1 and test 2

Condition classification of costal seawater from Norwegian Environmental Agency, are shown by listing the value "Class II Good" and "Class IV Poor" Appendix C.

Low concentration of copper in inlet seawater and reduced in the water treatment system. Low concentration of zinc (11 µg/l) and traces of lead in the inlet seawater and slight reduction through the water treatment system.

This confirms the assumption of contamination of Stenungsund samples with the components of copper, zinc and lead.

Vanadium is in the same level as in Stenungsund samples.

The values of Fenantren and Fluoranten is above good, but far below poor quality.

The value of Arsen as is approximately the same in and out, and above good, but far below poor.

Nickel that came from the HFO burned is between good and poor.

Pyren has values above quality good, but far below poor.

Vanadium is reduced in sample point 4 due to dilution with inlet seawater.

4 Environmental risk factor (PEC/PNEC)

Assuming the Stenungsund samples are contaminated with Cu, Zn and Pb from the sampling system, these are set to zero and a new environmental risk factor (PEC/PNEC) is calculated, see table below. The results show an emission factor for inlet seawater in the range of 8 – 11, which is slightly higher than at Kårstø.

Sum of environmental risk factor for net overboard samples are 58 and reduced to 15 when diluted with seawater. The main driver for environmental risk factor (PEC/PNEC) is vanadium, which is significantly reduced in the US VCP mode (added reaction water) due to high solubility in water.

Sampling	Stenungsund		Kårstø	
	Test 1	Test 3	Test 1	Test 2
Seawater inlet	45 (11)	48 (8)	7	5
After scrubber	758 (69)	405 (84)	95	76
Wash water overboard	1089 (63)	125 (23)	50	19
Net overboard	1052 (58)	78(15)	45	14

Sum of environmental risk factor (PEC/PNEC) for seawater inlet, after scrubber, wash water overboard and the concentration overboard (wash water overboard – seawater inlet), see appendix A. Number in brackets are PEC/PNEC values when eliminating Cu, Zn and Pb from samples in Stenungsund test 1 and test 3, see calculations in section 4.1

Stenungsund
With IMO operation, test 1, the wash water will recover to the same PEC/PNEC ratio as the inlet water when obtain a concentration 11/63 i.e. ~18% of the concentration at point of discharge.

With US EPA VGP operation, test 3, the PEC/PNEC ratio will recover to the same value as the inlet water when obtain a concentration 8/23 i.e. ~35% of the concentration at point of discharge.

Kårstø.
With IMO operation, test 1, the PEC/PNEC ratio will recover to the same level as the inlet value when obtain a concentration 7/50 i.e. ~14% of the concentration at point of discharge.

With US EPA VGP operation the PEC/PNEC ratio will recover to the same value as the inlet water when obtain a concentration 5/19 i.e. ~26% of the concentration at point of discharge.

Water cleaning system is crucial to obtain good quality of the wash water. The cleaning system is reducing all components except from Nickel and Vanadium. As an example PEC/PNEC on test 1 at Kårstø, 95 after scrubber reduced to 50 after cleaning system, a reduction of 48%.

Another good indicator is the amount of sludge collected in filter bags.

4.1 PEC/PNEC calculation of Stenungsund test 1 and test 3 eliminating Cu, Zn and Pb

PEC/PNEC calculation of test 1 Stenungsund eliminating Cu, Zn and Pb

	Predicted Environmental Concentrations (µg/L)				Predicted No Effect	PEC/PNEC ratios				
ELEMENT	water Inlet	After scrubber	Washwater overboard	Net overboard		Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	4,19	3,86	3,86	2	0,00	2,10	1,93	1,93	3,35
Acenaftylen	0	0	0	0	0,13	0,00	0,00	0,00	0,00	0,00
Acenaften	0	0,12	0,107	0,107	0,38	0,00	0,32	0,28	0,28	0,49
Fluoren	0	0,342	0,322	0,322	0,25	0,00	1,37	1,29	1,29	2,23
Fenantren	0	0,762	0,67	0,67	1,3	0,00	0,59	0,52	0,52	0,89
Antracen	0	0	0	0	0,1	0,00	0,00	0,00	0,00	0,00
Fluoranten	0	0,074	0,066	0,066	0,01	0,00	7,40	6,60	6,60	11,45
Pyren	0	0,072	0,064	0,064	0,023	0,00	3,13	2,78	2,78	4,83
Benso(a)antracen	0	0	0	0	0,0012	0,00	0,00	0,00	0,00	0,00
Krysen	0	0	0	0	0,007	0,00	0,00	0,00	0,00	0,00
Benso(b)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0	0	0	0,00082	0,00	0,00	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	5,85	5,77	2,47	0	0,6	9,75	9,62	4,12	0,00	0,00
Cd (Kadmium)	0	0	0	0	0,21	0,00	0,00	0,00	0,00	0,00
Co (Kobolt)	0	0	0,21	0,21	24,53	0,00	0,00	0,01	0,01	0,01
Cr (Krom)	0	1,32	1,91	1,91	0,6	0,00	2,20	3,18	3,18	5,52
Cu (Kopper)	0	0	0	0	2,6	0,00	0,00	0,00	0,00	0,00
Mo (Molybden)	8,63	8,77	9,07	0,44	7,3	1,18	1,20	1,24	0,06	0,10
Ni (Nikkel)	0,656	51,4	57,7	57,044	8,6	0,08	5,98	6,71	6,63	11,51
Pb (Bly)	0	0	0	0	1,3	0,00	0,00	0,00	0,00	0,00
V (Vanadium)	0,989	218	214	213,011	6,2	0,16	35,16	34,52	34,36	59,61
Zn (Sink)	0	0	0	0	4,9	0,00	0,00	0,00	0,00	0,00
					SUM	**11,17**	**69,05**	**63,17**	**57,64**	**100,00**

MARINTEK

PEC/PNEC calculation of test 3 Stenungsund eliminating Cu, Zn and Pb

	Predicted Environmental Concentrations (µg/L)				Predicted	PEC/PNEC ratios				
ELEMENT	Sea water Inlet	After scrubber	Washwater overboard	Net overboard		Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	4,1	0,136	0,136	2	0,00	2,05	0,07	0,07	0,44
Acenaftylen	0	0	0,018	0,018	0,13	0,00	0,00	0,14	0,14	0,90
Acenaften	0	0,1	0,03	0,03	0,38	0,00	0,26	0,08	0,08	0,52
Fluoren	0	0,326	0,115	0,115	0,25	0,00	1,30	0,46	0,46	3,00
Fenantren	0	0,769	0,255	0,255	1,3	0,00	0,59	0,20	0,20	1,28
Antracen	0	0	0	0	0,1	0,00	0,00	0,00	0,00	0,00
Fluoranten	0	0,103	0,023	0,023	0,01	0,00	10,30	2,30	2,30	15,01
Pyren	0	0,107	0,022	0,022	0,023	0,00	4,65	0,96	0,96	6,24
Benso(a)antracen	0	0,012	0	0	0,0012	0,00	10,00	0,00	0,00	0,00
Krysen	0	0,017	0	0	0,007	0,00	2,43	0,00	0,00	0,00
Benso(b)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0	0	0	0,00082	0,00	0,00	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	4,09	4,09	5,21	1,12	0,6	6,82	6,82	8,68	1,87	12,18
Cd (Kadmium)	0	0,0785	0	0	0,21	0,00	0,37	0,00	0,00	0,00
Co (Kobolt)	0	0,206	0	0	24,53	0,00	0,01	0,00	0,00	0,00
Cr (Krom)	0	1,43	0	0	0,6	0,00	2,38	0,00	0,00	0,00
Cu (Kopper)	0	0	0	0	2,6	0,00	0,00	0,00	0,00	0,00
Mo (Molybden)	8,44	8,35	8,94	0,5	7,3	1,16	1,14	1,22	0,07	0,45
Ni (Nikkel)	0,985	48	12,4	11,415	8,6	0,11	5,58	1,44	1,33	8,66
Pb (Bly)	0	0	0	0	1,3	0,00	0,00	0,00	0,00	0,00
V (Vanadium)	1,47	227	50,2	48,73	6,2	0,24	36,61	8,10	7,86	51,30
Zn (Sink)	0	0	0	0	4,9	0,00	0,00	0,00	0,00	0,00
					SUM	**8,32**	**84,51**	**23,64**	**15,32**	**100,00**

5 Dilution wash water emitted from the ship

Looking at the environmental influence in ambient water of scrubber discharges, the below figure shows a 150 meter vessel with a DN300 scrubber wash water outlet. Conventional turbulent jet theory shows that at 8.5 meters from the outlet, the concentration of discharged parameters is only 10% of the concentration at the outlet.

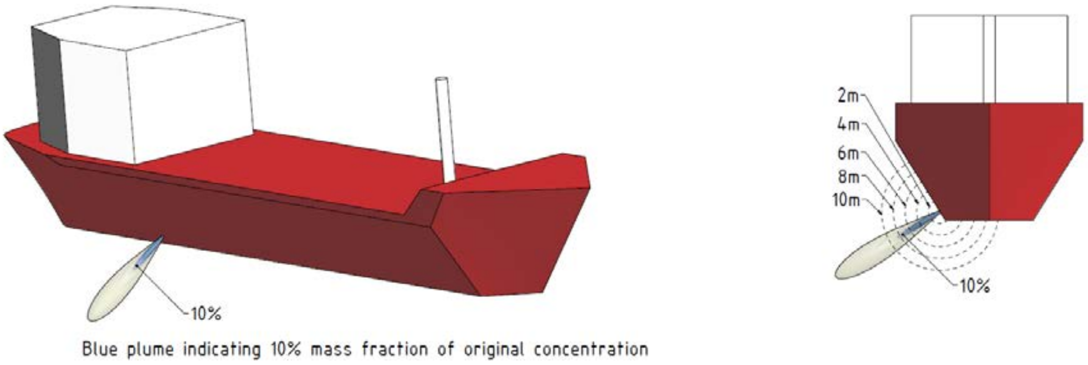

Figure showing concentration decrease in scrubber wash water discharge from a 150 meter long vessel (to scale).

This means that for a typical scrubber wash water heavy metal concentration (chromium, lead etc) of 0.5-2.0 µg/l, the resulting concentration 10 meters from the vessel will be <0.05–0.2 µg/l.
A more detailed picture of the turbulent jet dilution is shown below. This science is typically applied to predict dilution of municipal waste water discharges, somewhat similar to the application used here.

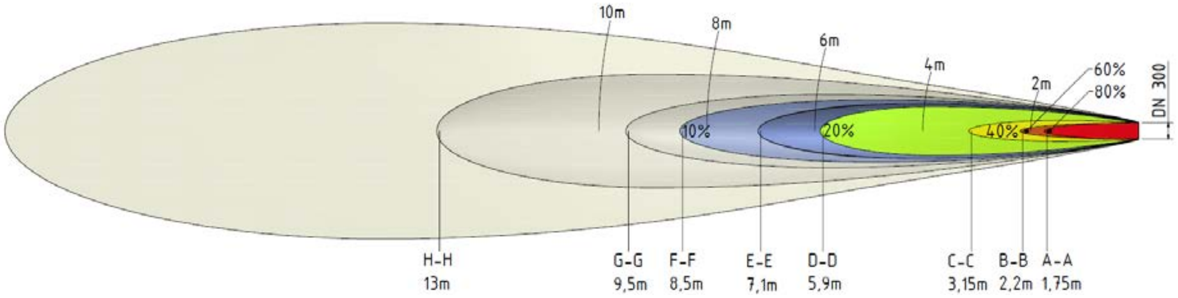

Figure showing concentration decrease of turbulent jet discharge from DN300 circular discharge.

Furthermore, the theory of turbulent jets is also used when setting the pH limit of the vessel according to MEPC 259(68). The pH recovery of acidic scrubber water in ambient water is a function of both dilution as described above and chemical neutralization, resulting in pH recovery to >6.5 four meters from point of discharge.

A SINTEF F27953 – Environmental risk characterization of wash water emitted from ships using EGR and scrubber technology – a PEC/PNEC approach

SINTEF F27953 - Restricted

Report

Environmental risk characterization of wash water emitted from ships using EGR and scrubber technology

A PEC/PNEC approach

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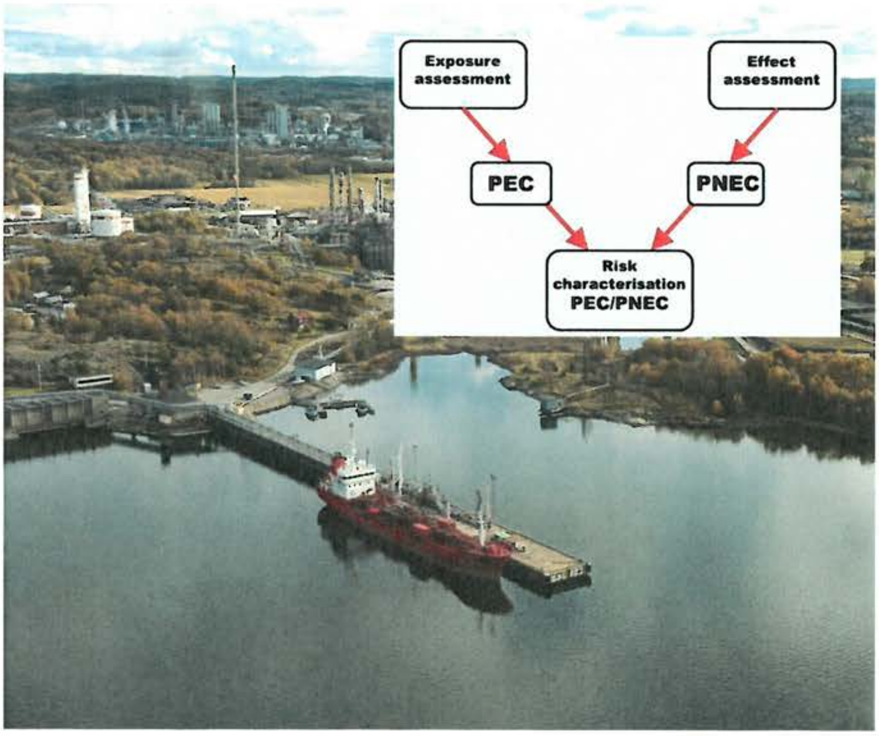

2016-11-28

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Report

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Environmental risk characterization of wash water emitted from ships using EGR and scrubber technology

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ABSTRACT

The basis for this report is to evaluate the potential risk of environmental effects of wash water emitted from ships equipped with exhaust gas recirculation (EGR) system and scrubber to reduce NOX emissions through exhaust. The authors received speciated concentrations of hydrocarbons, metals and water chemistry of process and wash water from the client. An environmental risk characterization was performed using these measured concentrations as "predicted exposure concentrations" (PEC) and "predicted no effect concentrations" (PNEC) in line with regulations for offshore emissions of produced water and production chemicals. PEC/PNEC ratios for all samples were estimated and potential risks characterized and risk drivers identified.

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1 Background and Introduction

This project was initiated by Solvang Shipping AS through MARINTEK in Trondheim. As part of their technology development using an exhaust gas recirculation (EGR) system and scrubber to reduce NOX emissions from ships running on HFO, they collected samples from the resulting wash water for analyses. These samples were analysed for polycyclic aromatic hydrocarbons and a selection of metals.
This report represent an assessment of the potential risk of environmental effects caused by the exposure to wash waters. The approach undertaken was estimating the ratio between the concentrations of specific components in wash water ("predicted environmental concentration", PEC) and a concentration level expected not to cause any acute and chronic effects on marine biota ("predicted no effect concentration", PNEC): PEC/PNEC-ratio. This represents a widely used approach to estimate the risk for environmental damage of chemical spills to the marine environment (Johnsen et al., 2000, Reed & Hetland, 2002; Frost et al., 2002; European Community, 2003; Rye et al., 2008; OSPAR, 2012).

2 Methodological approach

2.1 Data included in the analyses

We received the following information from the clients: Excel-based data reports from chemical analyses of water samples. The chemical analyses was performed by ALS Laboratory Group Norway AS under contract from Solvang ASA.

- N1612491 test 1 Stenungsund (undiluted)
- N1612493 test 3 Stenungsund (diluted)
- N1616941 test 1 Kårstø (undiluted)
- N1616942 test 2 Kårstø (diluted)

Samples test 1 (Stenungsund and Kårstø) represent process water from the cleaning technology prior to dilution with sea water (reaction water) from a side arm from the inlet for Inlet water. The samples test 3 (Stenungsund) and test 2 (Kårstø) represent process water diluted with inlet sea water (reaction water) on-board just prior to release into the sea from the vehicle.

The reported concentrations of individual components were used as PEC values in the PEC/PNEC calculations. Only data on single components from the analyses were used, not data on summarized fractions (e.g. Fraksjon >C10-C12 and Sum PAH carcinogen). There are no PNECs for these types of summarized "components", and for some of them (PAH carcinogen), the single components which are summarized are already represented in the compound list as single components.

We also received a document displaying a simulated dilution of scrubber discharge. This document was prepared by Wärtsila Moss AS for the clients.

2.2 Potential environmental damage

The risk of environmental damage is estimated as the ratio between the concentration of a given component Ci in the released wash water (predicted environmental concentration, PEC) and the predicted no effect concentration (PNEC) of the same component. The risk for the wash water is then the sum of PEC/PNEC ratios for all components included in the analyses. When the PEC/PNEC >1, there is a risk of environmental damage, and consequently the risk is low when PEC/PNEC<1 (European Community, 2003, Frost et al., 2003).

It is important to notice that the PNEC is a conservative value that describes a "safe" concentration of individual components where no impact is expected to occur for any organisms. The PEC/PNEC approach is therefore best suited to compare mixtures and identify components with the highest potential for environmental impact. The actual toxicity and thus the actual environmental risk can only be established through data on the toxicity of the mixture on relevant organisms and information on the magnitude of the spill (spill rate) and dilution and fate of the discharged components.

PECs were calculated for individual components by subtracting the concentration in the inlet seawater (SW Inlet) from the wash water (Water overboard) to estimate a "net overboard" concentration. Where concentrations measured were below the detection limit of the chemical analyses, the concentration was set to zero. When the concentration of a given component in the wash water was lower than in the inlet water (and the "net overboard" was a negative value), the "net overboard" was also given the value zero.

The PNECs used are given in Table 1. They are based on OSPAR regulations (OSPAR, 2012) for most of the components, but for some (cobalt, molybdenum and vanadium) PNECs were derived by dividing the lowest LC50 (concentration that causes 50% mortality on a test population of a given species and exposure time) for marine species found by a factor of 100. The LC50 data were found in the ECOTOX database (https://cfpub.epa.gov/ecotox/quick_query.htm).

Table 1: Predicted no effect concentrations (PNECs).

Component	PNEC (µg/L)	Source
Naftalen	2	OSPAR
Acenaftylen	0,13	OSPAR
Acenaften	0,38	OSPAR
Fluoren	0,25	OSPAR
Fenantren	1,3	OSPAR
Antracen	0,1	OSPAR
Fluoranten	0,01	OSPAR
Pyren	0,023	OSPAR
Benso(a)antracen	0,0012	OSPAR
Krysen	0,007	OSPAR
Benso(b)fluoranten	0,017	OSPAR
Benso(k)fluoranten	0,017	OSPAR
Benso(a)pyren	0,022	OSPAR
Dibenso(ah)antracen	0,00014	OSPAR
Benso(ghi)perylen	0,00082	OSPAR
Indeno(123cd)pyren	0,00027	OSPAR
As (Arsen)	0,6	OSPAR
Cd (Kadmium)	0,21	OSPAR
Co (Kobolt)	24,53	ECOTOX
Cr (Krom)	0,6	OSPAR

Cu (Kopper)	2,6	OSPAR
Mo (Molybden)	7,3	ECOTOX
Ni (Nikkel)	8,6	OSPAR
Pb (Bly)	1,3	OSPAR
V (Vanadium)	6,2	ECOTOX
Zn (Sink)	4,9	OSPAR

PEC/PNEC calculations were performed on all individual components and summarized to generate a total PEC/PNEC for the wash water.

3 Results and discussion

3.1 Stenungsund samples

Two water samples were analyzed from Stenungsund (test 1: N1612491 and test 3: N1612493). Concentrations and PEC/PNEC ratios for all Stenungsund samples are given in Table 2 (test 1) and 3 (test 3).

Estimated PEC/PNEC ratios for the net overboard wash water were 1052 and 78 for test 1 and test 3, respectively. Difference over an order of magnitude was found between the sample sampled directly after the on-board process prior to (test 1) and after mixing with sea water on-board just prior to release into sea water (test 3), suggesting that mixture with reaction water reduces the potential toxicity of wash water spill significantly.

Copper is the main driver for the elevated PEC/PNEC ratio with 90 and 74% contribution to the sum PEC/PNEC in test 1 and 3, respectively. The main reason for the elevated Cu concentrations appears to be that samples were taken through a copper side branch in the onboard system, and not because there is a process-based increase in copper levels of the wash water. By taking water samples through a different (non-Cu-containing tubing) would decrease the Cu concentrations. Other PEC/PNEC drivers are vanadium, zinc, fluoranthene, nickel, pyrene and chromium, but these are very low compared to copper (<5% of total PEC/PNEC).

Interestingly, the Sea water Inlet samples from this location displayed relatively high PEC/PNEC-ratios (45 and 48), suggesting that the water in Stenungsund is contaminated. The analyses suggested that the contamination of highest concern is Zn, As, Cu and Pb.

Table 2: Predicted Environmental Concentrations (PEC), Predicted No Effect Concentrations (PNEC) and PEC/PNEC-ratios for N1612491 test 1 Stenungsund. PECs (in µg/L) of individual PAHs and elements in seawater (Sea water Inlet), partly processed water (After scrubber, before cleaning), wash water (Water overboard) and net wash water (Net overboard). Calculated PEC/PNEC ratios for individual components and sums for all water samples are also given.

	Predicted Environmental Concentrations (µg/L)				Predicted No Effect Concentration (µg/L)	PEC/PNEC ratios				
Compound	Sea water Inlet	After scrubber	Washwater overboard	Net overboard		Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	4,19	3,86	3,86	2	0,00	2,10	1,93	1,93	0,18
Acenaftylen	0	0	0	0	0,13	0,00	0,00	0,00	0,00	0,00
Acenaften	0	0,12	0,107	0,107	0,38	0,00	0,32	0,28	0,28	0,03
Fluoren	0	0,342	0,322	0,322	0,25	0,00	1,37	1,29	1,29	0,12
Fenantren	0	0,762	0,67	0,67	1,3	0,00	0,59	0,52	0,52	0,05
Antracen	0	0	0	0	0,1	0,00	0,00	0,00	0,00	0,00
Fluoranten	0	0,074	0,066	0,066	0,01	0,00	7,40	6,60	6,60	0,63
Pyren	0	0,072	0,064	0,064	0,023	0,00	3,13	2,78	2,78	0,26
Benso(a)antracen	0	0	0	0	0,0012	0,00	0,00	0,00	0,00	0,00
Krysen	0	0	0	0	0,007	0,00	0,00	0,00	0,00	0,00
Benso(b)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0	0	0	0,00082	0,00	0,00	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	5,85	5,77	2,47	0	0,6	9,75	9,62	4,12	0,00	0,00
Cd (Kadmium)	0	0	0	0	0,21	0,00	0,00	0,00	0,00	0,00
Co (Kobolt)	0	0	0,21	0,21	24,53	0,00	0,00	0,01	0,01	0,00
Cr (Krom)	0	1,32	1,91	1,91	0,6	0,00	2,20	3,18	3,18	0,30
Cu (Kopper)	14,8	1240	2490	2475,2	2,6	5,69	476,92	957,69	952,00	90,49
Mo (Molybden)	8,63	8,77	9,07	0,44	7,3	1,18	1,20	1,24	0,06	0,01
Ni (Nikkel)	0,656	51,4	57,7	57,044	8,6	0,08	5,98	6,71	6,63	0,63
Pb (Bly)	3,71	86,7	0,553	0	1,3	2,85	66,69	0,43	0,00	0,00
V (Vanadium)	0,989	218	214	213,011	6,2	0,16	35,16	34,52	34,36	3,27
Zn (Sink)	122	714	330	208	4,9	24,90	145,71	67,35	42,45	4,03
					SUM	**44,61**	**758,38**	**1088,64**	**1052,09**	**100,00**

Table 3: Predicted Environmental Concentrations (PEC), Predicted No Effect Concentrations (PNEC) and PEC/PNEC-ratios for N1612493 test 3 Stenungsund. PECs (in µg/L) of individual PAHs and elements in seawater (Sea water Inlet), partly processed water (After scrubber, before cleaning), wash water (Water overboard) and net wash water (Net overboard). Calculated PEC/PNEC ratios for individual components and sums for all water samples are also given.

	Predicted Environmental Concentrations (µg/L)				Predicted No Effect Concentration (µg/L)	PEC/PNEC ratios				
Compound	Sea water Inlet	After scrubber	Washwater overboard	Net overboard		Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	4,1	0,136	0,136	2	0,00	2,05	0,07	0,07	0,09
Acenaftylen	0	0	0,018	0,018	0,13	0,00	0,00	0,14	0,14	0,18
Acenaften	0	0,1	0,03	0,03	0,38	0,00	0,26	0,08	0,08	0,10
Fluoren	0	0,326	0,115	0,115	0,25	0,00	1,30	0,46	0,46	0,59
Fenantren	0	0,769	0,255	0,255	1,3	0,00	0,59	0,20	0,20	0,25
Antracen	0	0	0	0	0,1	0,00	0,00	0,00	0,00	0,00
Fluoranten	0	0,103	0,023	0,023	0,01	0,00	10,30	2,30	2,30	2,93
Pyren	0	0,107	0,022	0,022	0,023	0,00	4,65	0,96	0,96	1,22
Benso(a)antracen	0	0,012	0	0	0,0012	0,00	10,00	0,00	0,00	0,00
Krysen	0	0,017	0	0	0,007	0,00	2,43	0,00	0,00	0,00
Benso(b)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0	0	0	0,00082	0,00	0,00	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	4,09	4,09	5,21	1,12	0,6	6,82	6,82	8,68	1,87	2,38
Cd (Kadmium)	0	0,0785	0	0	0,21	0,00	0,37	0,00	0,00	0,00
Co (Kobolt)	0	0,206	0	0	24,53	0,00	0,01	0,00	0,00	0,00
Cr (Krom)	0	1,43	0	0	0,6	0,00	2,38	0,00	0,00	0,00
Cu (Kopper)	38,2	568	191	152,8	2,6	14,69	218,46	73,46	58,77	74,98
Mo (Molybden)	8,44	8,35	8,94	0,5	7,3	1,16	1,14	1,22	0,07	0,09
Ni (Nikkel)	0,985	48	12,4	11,415	8,6	0,11	5,58	1,44	1,33	1,69
Pb (Bly)	1,49	93,9	0	0	1,3	1,15	72,23	0,00	0,00	0,00
V (Vanadium)	1,47	227	50,2	48,73	6,2	0,24	36,61	8,10	7,86	10,03
Zn (Sink)	116	147	137	21	4,9	23,67	30,00	27,96	4,29	5,47
					SUM	**47,84**	**405,20**	**125,07**	**78,38**	**100,00**

3.2 Kårstø samples

Two water samples were analysed from Kårstø (test 1: N1616941 and test 2: N1616942). Concentrations and PEC/PNEC ratios for all Kårstø samples are given in Table 4 (test 1) and Table 5 (test 2).

Estimated PEC/PNEC ratios for the net overboard wash water were 45 and 14 for test 1 and test 2, respectively. Difference of a factor of three between the sample sampled directly after the on-board process prior to (test 1) and after mixing with sea water on-board just prior to release into sea water (test 2 significantly reduces the toxicity of the discharge mixture

Vanadium is the main driver for the elevated PEC/PNEC ratio with 58 and 47% contribution to the sum PEC/PNEC in test 1 and 2, respectively. Vanadium is expected to be originating from the fuel oil. Other PEC/PNEC drivers are zinc, fluoranthene, nickel, pyrene and fluorene, but these are very low compared to vanadium (<7% of total PEC/PNEC).

The Sea water Inlet samples (background levels) from this location displayed lower PEC/PNEC-ratios compared to Stenungsund.

Table 4: Predicted Environmental Concentrations (PEC), Predicted No Effect Concentrations (PNEC) and PEC/PNEC-ratios for N1616941 test 1 Kårstø. PECs (in µg/L) of individual PAHs and elements in seawater (Sea water Inlet), partly processed water (After scrubber, before cleaning), wash water (Water overboard) and net wash water (Net overboard). Calculated PEC/PNEC ratios for individual components and sums for all water samples are also given.

	Predicted Environmental Concentrations (µg/L)				Predicted No Effect	PEC/PNEC ratios				
Compound	Sea water Inlet	After scrubber	Washwater overboard	Net overboard	**Concentration (µg/L)**	Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	1,99	1,85	1,85	2	0,00	1,00	0,93	0,93	2,05
Acenaftylen	0	0,027	0,026	0,026	0,13	0,00	0,21	0,20	0,20	0,44
Acenaften	0	0,126	0,115	0,115	0,38	0,00	0,33	0,30	0,30	0,67
Fluoren	0	0,367	0,319	0,319	0,25	0,00	1,47	1,28	1,28	2,83
Fenantren	0	1,19	0,998	0,998	1,3	0,00	0,92	0,77	0,77	1,70
Antracen	0	0	0	0	0,1	0,00	0,00	0,00	0,00	0,00
Fluoranten	0	0,125	0,065	0,065	0,01	0,00	12,50	6,50	6,50	14,39
Pyren	0	0,101	0,046	0,046	0,023	0,00	4,39	2,00	2,00	4,43
Benso(a)antracen	0	0,016	0	0	0,0012	0,00	13,33	0,00	0,00	0,00
Krysen	0	0,012	0	0	0,007	0,00	1,71	0,00	0,00	0,00
Benso(b)fluoranten	0	0,021	0	0	0,017	0,00	1,24	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0,012	0	0	0,00082	0,00	14,63	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	1,75	1,78	1,61	0	0,6	2,92	2,97	2,68	0,00	0,00
Cd (Kadmium)	0	0	0	0	0,21	0,00	0,00	0,00	0,00	0,00
Co (Kobolt)	0	0	0	0	24,53	0,00	0,00	0,00	0,00	0,00
Cr (Krom)	0	1,87	0	0	0,6	0,00	3,12	0,00	0,00	0,00
Cu (Kopper)	4,32	1,57	1,05	0	2,6	1,66	0,60	0,40	0,00	0,00
Mo (Molybden)	11,1	11,7	10,5	0	7,3	1,52	1,60	1,44	0,00	0,00
Ni (Nikkel)	0,917	46,4	41,7	40,783	8,6	0,11	5,40	4,85	4,74	10,50
Pb (Bly)	0,759	0,527	0	0	1,3	0,58	0,41	0,00	0,00	0,00
V (Vanadium)	1,27	168	164	162,73	6,2	0,20	27,10	26,45	26,25	58,11
Zn (Sink)	0	11	10,8	10,8	4,9	0,00	2,24	2,20	2,20	4,88
					SUM	**6,99**	**95,16**	**50,00**	**45,16**	**100,00**

Table 5: Predicted Environmental Concentrations (PEC), Predicted No Effect Concentrations (PNEC) and PEC/PNEC-ratios for N1616942 test 2 Kårstø. PECs (in µg/L) of individual PAHs and elements in seawater (Sea water Inlet), partly processed water (After scrubber, before cleaning), wash water (Water overboard) and net wash water (Net overboard). Calculated PEC/PNEC ratios for individual components and sums for all water samples are also given.

	Predicted Environmental Concentrations (µg/L)				Predicted No Effect Concentration (µg/L)	PEC/PNEC ratios				
ELEMENT	Sea water Inlet	After scrubber	Washwater overboard	Net overboard		Sea water Inlet	After scrubber	Washwater overboard	Net overboard	% of total (net overboard)
Naftalen	0	1,64	0,407	0,407	2	0,00	0,82	0,20	0,20	1,47
Acenaftylen	0	0,029	0,032	0,032	0,13	0,00	0,22	0,25	0,25	1,78
Acenaften	0	0,093	0,031	0,031	0,38	0,00	0,24	0,08	0,08	0,59
Fluoren	0	0,291	0,078	0,078	0,25	0,00	1,16	0,31	0,31	2,25
Fenantren	0	1,03	0,275	0,275	1,3	0,00	0,79	0,21	0,21	1,53
Antracen	0	0,014	0	0	0,1	0,00	0,14	0,00	0,00	0,00
Fluoranten	0	0,075	0,018	0,018	0,01	0,00	7,50	1,80	1,80	12,99
Pyren	0	0,09	0,031	0,031	0,023	0,00	3,91	1,35	1,35	9,73
Benso(a)antracen	0	0,017	0	0	0,0012	0,00	14,17	0,00	0,00	0,00
Krysen	0	0,023	0	0	0,007	0,00	3,29	0,00	0,00	0,00
Benso(b)fluoranten	0	0,013	0	0	0,017	0,00	0,76	0,00	0,00	0,00
Benso(k)fluoranten	0	0	0	0	0,017	0,00	0,00	0,00	0,00	0,00
Benso(a)pyren	0	0	0	0	0,022	0,00	0,00	0,00	0,00	0,00
Dibenso(ah)antracen	0	0	0	0	0,00014	0,00	0,00	0,00	0,00	0,00
Benso(ghi)perylen	0	0	0	0	0,00082	0,00	0,00	0,00	0,00	0,00
Indeno(123cd)pyren	0	0	0	0	0,00027	0,00	0,00	0,00	0,00	0,00
As (Arsen)	1,7	1,58	1,59	0	0,6	2,83	2,63	2,65	0,00	0,00
Cd (Kadmium)	0	0	0	0	0,21	0,00	0,00	0,00	0,00	0,00
Co (Kobolt)	0	0	0	0	24,53	0,00	0,00	0,00	0,00	0,00
Cr (Krom)	0	1,51	0	0	0,6	0,00	2,52	0,00	0,00	0,00
Cu (Kopper)	1,47	1,1	1,23	0	2,6	0,57	0,42	0,47	0,00	0,00
Mo (Molybden)	10,9	11,3	10,7	0	7,3	1,49	1,55	1,47	0,00	0,00
Ni (Nikkel)	1,7	46,1	11,2	9,5	8,6	0,20	5,36	1,30	1,10	7,97
Pb (Bly)	0	0	0	0	1,3	0,00	0,00	0,00	0,00	0,00
V (Vanadium)	1,63	175	41,6	39,97	6,2	0,26	28,23	6,71	6,45	46,53
Zn (Sink)	0	11,5	10,3	10,3	4,9	0,00	2,35	2,10	2,10	15,17
					SUM	**5,35**	**76,07**	**18,91**	**13,86**	**100,00**

When PEC/PNEC is >1 there is a risk of environmental damage. When summarizing PEC/PNECs for all measured components, the wash water display a total PEC/PNEC of 47. The main risk drivers (components displaying PEC/PNEC >1) are vanadium (55.8%), fluoranthene (13.8%), nickel (10.1%), zinc (4.7%), pyrene (4.3%), molybdenum (3.1%), fluorene (2.7%) and naphthalene (2.0%).

3.3 Aspects affecting concentrations in the environment

Importantly, these PEC/PNEC ratios relate only to the wash water released from the boat, and does not take into account the dilution of the wash water in the environment. As such, using the analytical data as PEC values overestimates the PEC/PNEC ratios dramatically compared to actual environmental concentrations. At offshore oil production platforms where produced water is emitted directly to the marine environment, PEC/PNEC ratios for the produced water are always >1 at the release site, but decrease rapidly due to dilution in the water. For the Stenungsund and Kårstø wash water, a dilution of 1 L wash water with 78 and 14 L seawater, respectively, would yield PEC/PNEC ratios of 1. As soon as the wash water is released from the vessel, external forces influence the dilution. Close to the released plume, the turbulence generated from the release itself will be the most important factor. When the wash water plume moves away from the release point, the turbulence will decrease, the plume will lose its momentum. The ambient current together with turbulence generated from waves/wind will then be the driving forces for the dilution. A model simulation by Wärtsila (dilution model DN300) suggests a dilution to 10% only 8.5 meters away from the vessel.

Other factors to take into account will be the solubility of the components in the wash water and density difference between the wash water and the ambient water. If the density of the wash water is close to the ambient, it will be spread and diluted more than if it is heavier than the ambient. Additionally, heavier particles in the wash water may be separated and sink to the seabed close to the release point.

4 Conclusion

A summary table of the environmental risk analyses is given in Table 6 below displaying the sum PEC/PNEC ratios for all water samples.

Table 6: Sum PEC/PNEC ratios for the three water samples taken (during and after on-board processing) and estimated Net overboard sample.

	Stenungsund		Kårstø	
	Test 1	Test 3	Test 1	Test 2
Sea water Inlet	45	48	7	5
After scrubber	758	405	95	76
Wash water overboard	1089	125	50	19
Net overboard	1052	78	45	14

Based on the environmental risk characterization performed on the analytical data, the following conclusions can be made:

- The two harbour areas used in the survey display differences in background level of contaminants, and Stenungsund is the most contaminated. Both, however, display PEC/PNEC-ratios >1 suggesting risk of environmental damage.

- Brass alloy tubing in the boat sampled for the Stenungsund survey caused an artificially high PEC/PNEC ratio and subsequent artificial increase in risk of environmental damage. To provide realistic analyses, samples should be taken using different type of tubing. The PEC/PNEC ratio without copper would be 100 (not 1052).
- Although the cleaning process increases contamination of the wash water, dilution with reaction water prior to release reduces the overall risk of environmental damage significantly.
- An overall increase in PEC/PNEC by a ratio of 2 when comparing inlet water and Net overboard water after dilution with reaction water (Test 3 for Stenungsund and Test 2 for Kårstø) suggest a very moderate overall increase in risk of environmental damage in both test areas/boats.

In an attempt to reduce any uncertainty relating to potential environmental effects of the wash water, toxicity testing of the wash water using local marine species could be conducted using serially diluted wash water. Thereafter, a near-field model simulation predicting the PEC in time (3D) and space would give a more realistic PEC/PNEC for the given harbour area. This would probably yield a much lower PEC/PNEC than estimated in the current report as the PEC would be based on a spill scenario (in time and space) and the PNEC will be based on real data on local species.

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B M608 - Grenseverdier for klassifisering av vann, sediment og biota

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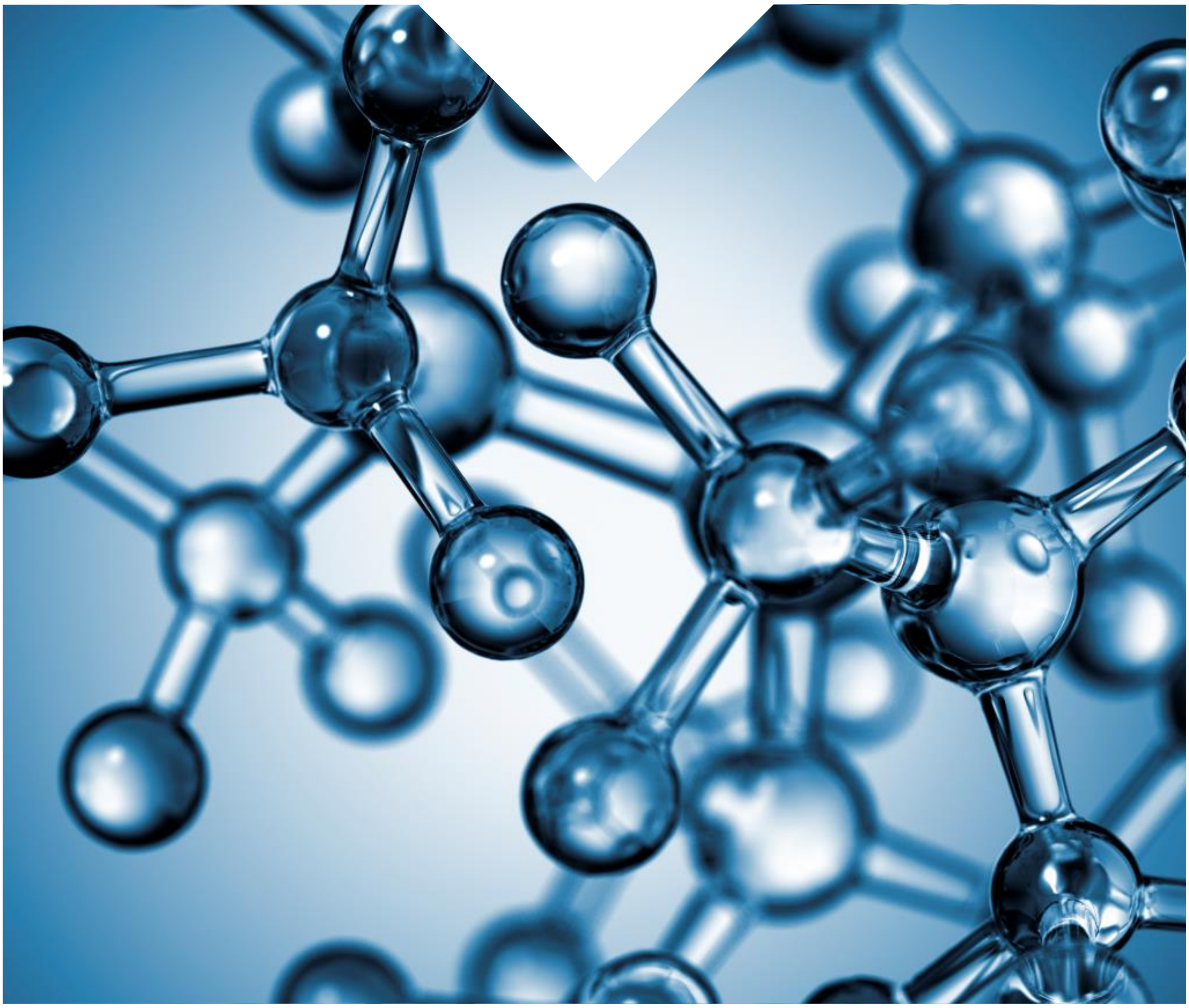
Grenseverdier for klassifisering av vann, sediment og biota



KOLOFON

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Oppdragstakers prosjektansvarlig

-

Kontaktperson i Miljødirektoratet

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M-nummer	År	Sidetall	Miljødirektoratets kontraktnummer
608	2016	24	-

Utgiver

Miljødirektoratet

Prosjektet er finansiert av

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Forfatter(e)

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Tittel - norsk og engelsk

Grenseverdier for klassifisering av vann, sediment og biota - Quality standards for water, sediment and biota

Sammendrag - summary

I forbindelse med revisjon av veiledning for klassifisering av miljøtilstand i vann publiseres med dette nye grenseverdier for metaller og organiske miljøgifter i vann, sediment og biota. Veilederen baserer seg på data fra rapportene TA-3001/2012 og M-241/2014 og er en sammenstilling av grenseverdier til bruk for klassifisering av miljøtilstand i vann, sediment og biota.

4 emneord

Miljøkvalitetsstandarder, grenseverdier, tilstandsklasser, miljøgifter

4 subject words

Environmental quality standards, limit values, classes for environmental condition, contaminants

Forsidefoto

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Innholdsfortegnelse

Grenseverdier og klassifisering i vann, sediment og biota

I 2015 ble Vannforskriften oppdatert med nye grenseverdier og stoffer. Vannforskriften inneholder nå grenseverdier i vann for 45 prioriterte miljøgifter, i biota for 23 prioriterte miljøgifter og i sediment for 28 prioriterte miljøgifter. I tillegg har Miljødirektoratet fått utarbeidet en rekke grenseverdier i vann, biota og sediment for vannregionspesifikke stoffer.

Miljødirektoratet har også fått laget klassegrenser i vann og sediment for både prioriterte miljøgifter og vannregionspesifikke miljøgifter. Grenseverdiene og klassegrensene for sedimenter er i hovedsak laget for marine sedimenter. For noen stoffer er det også laget grenseverdier og klassegrenser for sedimenter i ferskvann. Det er ikke utviklet klassegrenser for biota.

Klassifiseringssystemet skal være et felles verktøy for ulike faggrupper og saksbehandlere innen forvaltning, rådgivning og forskning for vurdering og bestemmelse av miljøtilstand i forskjellige vannforekomster. Grenseverdiene og klassegrensene er utarbeidet av Aquateam (rapport TA-3001/2012) og kvalitetssikret av NIVA i samarbeid med NGI (rapport M-241|2014). Kriteriene for fastlegging av klassegrensene er basert på internasjonalt etablerte systemer for miljøkvalitetsstandarder og risikovurdering av kjemikalier i EU, og grenseverdiene er utarbeidet som beskrevet i Technical Guidance Document for Deriving Environmental Quality Standards (TGD. No. 27).

De nye grenseverdiene og klassegrensene erstatter Miljødirektoratets grenseverdier og klassegrenser i klassifiseringsveilederne TA-2229/2007 og TA-1467/1997 (Veiledere for klassifisering av miljøkvalitet i fjorder og kystfarvann).

I Bakgrunn	II God	III Moderat	IV Dårlig	V Svært dårlig
Bakgrunnsnivå	Ingen toksiske effekter	Kroniske effekter ved langtids-eksponering	Akutt toksiske effekter ved kort-tidseksponering	Omfattende toksiske effekter
Øvre grense: bakgrunn	Øvre grense: AA-QS, PNEC	Øvre grense: MAC-QS, $PNEC_{akutt}$	Øvre grense: $PNEC_{akutt}$* AF[1)]	

Figur: Klassifiseringssystem for vann og sediment. 1) AF: sikkerhetsfaktor

I klassifiseringssystemet representerer klassegrensene en forventet økende grad av skade på organismesamfunnet i vannsøylen og sedimentene. Grensene er basert på tilgjengelig informasjon fra laboratorietester, risikovurderinger og dossierer om akutt og kronisk toksisitet på organismer.

Kriteriene for øvre grense for klasse II og III i klassifiseringssystemet er i samsvar med Vanndirektivets miljøkvalitetsstandarder AA-EQS og MAC-EQS. Øvre grense for klasse II tilsvarer AA-EQS, som er grenseverdien for kroniske effekter ved langtidseksponering, og øvre grense for klasse III tilsvarer MAC-EQS, som er grenseverdien for akutt toksiske effekter ved korttidseksponering. Øvre grense for klasse I representerer bakgrunnsverdier, og naturtilstanden der slike data foreligger. For de fleste av de menneskeskapte miljøgiftene og der miljøgiften ikke har en naturlig kilde er øvre grense for klasse I satt til null. Øvre grense for klasse IV er basert på akutt toksisitet uten sikkerhetsfaktorer, og er grensen for mer omfattende akutte toksiske effekter. Alle klassegrensene utenom øvre grense for klasse I er beregnet ut fra risiko/effekt.

Klassifiseringssystemet for sedimenter er beregnet til bruk for finkornet sediment, bestående av leire og/eller silt. Ettersom miljøgifter i hovedsak er knyttet til små partikler og organisk materiale vil ikke sedimenter med innslag av grus eller grov sand være egnet for vurdering gjennom dette systemet. Grenseverdiene er også tilpasset norske forhold. Det er blant annet lagt til grunn et innhold av organisk karbon i sedimentet på 1 %, som er lavere enn hva som benyttes innenfor EU. Dette skyldes at innholdet av organisk karbon er lavere i Norge enn i mange EU-land.

Grenseverdiene og klassegrensene (med unntak av klasse I) er fastsatt på bakgrunn av tilgjengelig informasjon om miljøgiftene fra økotoksikologiske laboratorietester. For å sikre tilstrekkelig beskyttelse der hvor det ikke finnes nok data benyttes sikkerhetsfaktorer (AF). Gjennom å legge på sikkerhetsfaktorer tar man tar høyde for eventuelle organismer som er mer følsomme enn dem man har brukt i laboratorietester. Sikkerhetsfaktoren blir lavere jo flere forskjellige typer organismer man har testet stoffet på.

Det ligger også en usikkerhet i klassegrensene for øvre grense for klasse I. Det skyldes blant annet mangel på analysedata fra upåvirkede områder (referansedata), for høye deteksjonsgrenser ved kjemisk analyse og at naturlig innhold av stoffer (slik som tungmetaller) varierer fra område til område.

Grenseverdier for miljøkvalitet i biota må ikke forveksles med grenseverdier for mattrygghet og omsetning av sjømat. For grenseverdier av miljøgifter i mat, se www.mattilsynet.no.
For en mer detaljert beskrivelse av utarbeidelsen av grenseverdiene og klassegrensene se TA-3001/2012 og M-241|2014.

Vurdering av kjemisk tilstand - basert på prøver i sediment
Dersom grenseverdier for kjemisk tilstand i sedimentet overskrides, bør det gjennomføres en risikovurdering av sedimentet for å vurdere om sedimentet utgjør en risiko for menneske og miljø og spredning til omgivelsene, før tiltak vurderes. Prøvetaking og risikovurdering skal gjennomføres som beskrevet i Miljødirektoratets veileder for risikovurdering av forurenset sediment benyttes (M-409|2015).

Prøvetaking i sediment
Prøvens representativitet må vurderes (bl.a. må det innhentes informasjon på kornfordeling, innhold av organisk stoff og prøvens utseende). Antall prøvestasjoner og hvor dypt i sedimentet det skal prøvetas må vurderes ut fra hensikten med undersøkelsen. For risikovurdering av forurenset sediment skal undersøkelsene gjennomføres som beskrevet i Miljødirektoratets veileder for risikovurdering av forurenset sediment (M-409|2015).). Se også

vedlegg VII i Veileder for håndtering av sedimenter (M-350|2015) for mer informasjon om prøvetaking ved undersøkelser og overvåking.

1. Grenseverdier for klassifisering av prioriterte stoffer og vannregionspesifikke stoffer under vannforskriften

1.1 Miljøkvalitetsstandarder For prioriterte stoffer og prioritert farlige stoffer i ferskvann og kystvann.

Miljøkvalitetsstandarder i vann er angitt i µg/l

Nr	Navn på substans	CAS-nr.[1]	Årlig gjennomsnitt[2] for ferskvann[3]	Årlig gjennomsnitt[2] for kystvann	Maksimal verdi[4] for ferskvann[3]	Maksimal verdi[4] for kystvann
1	Alaklor	15972-60-8	0,3	0,3	0,7	0,7
2	Antracen[A]	120-12-7	0,1	0,1	0,1	0,1
3	Atrazin	1912-24-9	0,6	0,6	2,0	2,0
4	Benzen	71-43-2	10	8	50	50
5	Bromerte difenyletere[A] [5]	32534-81-9			0,14	0,014
6	Kadmium og kadmium-forbindelser[A] [6] (avhengig av vannets hardhet)	7440-43-9	≤ 0,08 (klasse 1) 0,08 (klasse 2) 0,09 (klasse 3) 0,15 (klasse 4) 0,25 (klasse 5)	0,2	≤ 0,45 (klasse 1) 0,45 (klasse 2) 0,6 (klasse 3) 0,9 (klasse 4) 1,5 (klasse 5)	≤ 0,45 (klasse 1) 0,45 (klasse 2) 0,6 (klasse 3) 0,9 (klasse 4) 1,5 (klasse 5)
7	Kortkjedete klorparafiner (C10-13)[A] [7]	85535-84-8	0,4	0,4	1,4	1,4
8	Klorfenvinfos	470-90-6	0,1	0,1	0,3	0,3
9	Klorpyrifos	2921-88-2	0,03	0,03	0,1	0,1
10	1,2-Dikloretan	107-06-2	10	10	Ikke oppgitt	Ikke oppgitt

Nr	Navn på substans	CAS-nr.[1]	Årlig gjennomsnitt[2] for ferskvann[3]	Årlig gjennomsnitt[2] for kystvann	Maksimal verdi[4] for ferskvann[3]	Maksimal verdi[4] for kystvann
11	Diklorometan	75-09-2	20	20	Ikke oppgitt	Ikke oppgitt
12	Di(2-etylheksyl)ftalat (DEHP)[A]	117-81-7	1,3	1,3	Ikke oppgitt	Ikke oppgitt
13	Diuron	330-54-1	0,2	0,2	1,8	1,8
14	Endosulfan[A]	115-29-7	0,005	0,0005	0,01	0,004
15	Fluoranten	206-44-0	0,0063	0,0063	0,12	0,12
16	Heksaklorbenzen[A]	118-74-1			0,05	0,05
17	Heksaklorbutadien[A]	87-68-3			0,6	0,6
18	Heksaklor- sykloheksan[A]	608-73-1	0,02	0,002	0,04	0,02
19	Isoproturon	34123-59-6	0,3	0,3	1,0	1,0
20	Bly og blyforbindelser	7439-92-1	1,2[8]	1,3	14	14
21	Kvikksølv og kvikksølv forbindelser[A]	7439-97-6			0,07	0,07
22	Naftalen	91-20-3	2	2	130	130
23	Nikkel og nikkelforbindelser	7440-02-0	4[8]	8,6	34	34
24	Nonylfenoler (4-nonylfenol)[A 9]	84852-15-3	0,3	0,3	2,0	2,0
25	Oktylfenol 4-(1,1,3,3-tetrametylbutyl)fenol[10]	140-66-9	0,1	0,01	Ikke oppgitt	Ikke oppgitt
26	Pentaklorbenzen[A]	608-93-5	0,007	0,0007	Ikke oppgitt	Ikke oppgitt
27	Pentaklorfenol	87-86-5	0,4	0,4	1,0	1,0
28	Polyaromatiske hydrokarboner (PAH)[A 11]	Ikke relevant	Ikke oppgitt	Ikke oppgitt	Ikke oppgitt	Ikke oppgitt
	Benzo(a)pyren	50-32-8	$1,7x10^{-4}$	$1,7x10^{-4}$	0,27	0,027
	Benzo(b)fluoranten	205-99-2	Se fotnote 11	Se fotnote 11	0,017	0,017

Nr	Navn på substans	CAS-nr.[1]	Årlig gjennomsnitt[2] for ferskvann[3]	Årlig gjennomsnitt[2] for kystvann	Maksimal verdi[4] for ferskvann[3]	Maksimal verdi[4] for kystvann
	Benzo(k)fluoranten	207-08-9	Se fotnote 11	Se fotnote 11	0,017	0,017
	Benzo(g,h,i)perylen	191-24-2	Se fotnote 11	Se fotnote 11	$8,2x10^{-3}$	$8,2x10^{-4}$
	Indeno(1,2,3-cd)pyren	193-39-5	Se fotnote 11	Se fotnote 11	Ikke oppgitt	Ikke oppgitt
29	Simazin	122-34-9	1,0	1,0	4,0	4,0
30	Tributyltinn forbindelser (tributyltinn kation)[A]	36643-28-4	0,0002	0,0002	0,0015	0,0015
31	Triklorbenzener	12002-48-1	0,4	0,4	Ikke oppgitt	Ikke oppgitt
32	Triklormetan (Kloroform)	67-66-3	2,5	2,5	Ikke oppgitt	Ikke oppgitt
33	Trifluralin[A]	1582-09-8	0,03	0,03	Ikke oppgitt	Ikke oppgitt
34 [12]	Dicofol[A]	115-32-2	$1,3 \times 10^{-3}$	$3,2 \times 10^{-5}$	Ikke oppgitt[13]	Ikke oppgitt[13]
35 [12]	Perfluoroktylsulfonat og dets derivater (PFOS)[A]	1763-23-1	$6,5 \times 10^{-4}$	$1,3 \times 10^{-4}$	36	7,2
36 [12]	Quinoxyfen[A]	124495-18-7	0,15	0,015	2,7	0,54
37 [12]	Dioksin og dioksinlignende forbindelser[A]	Se fotnote 14			Ikke oppgitt	Ikke oppgitt
38 [12]	Aklonifen	74070-46-5	0,12	0,012	0,12	0,012
39 [12]	Bifenox	42576-02-3	0,012	0,0012	0,04	0,004
40 [12]	Cybutryne	28159-98-0	0,0025	0,0025	0,016	0,016
41 [12]	Cypermetrin[15]	52315-07-8	8×10^{-5}	8×10^{-6}	6×10^{-4}	6×10^{-5}
42 [12]	Diklorvos	62-73-7	6×10^{-4}	6×10^{-5}	7×10^{-4}	7×10^{-5}

Nr	Navn på substans	CAS-nr.[1]	Årlig gjennomsnitt[2] for ferskvann[3]	Årlig gjennomsnitt[2] for kystvann	Maksimal verdi[4] for ferskvann[3]	Maksimal verdi[4] for kystvann
43 [12]	Heksabromsyklododekan (HBCDD)[A]	Se fotnote 16	0,0016	0,0008	0,5	0,05
44 [12]	Heptaklor og heptaklorepoksid[A]	76-44-8/1024-57-3	2×10^{-7}	1×10^{-8}	3×10^{-4}	3×10^{-5}
45 [12]	Terbutryn	886-50-0	0,065	0,0065	0,34	0,034

1 CAS- Chemical Abstracs service.

2 Den gjennomsnittlige årlige verdien. Hvis ikke annet er oppgitt svarer denne verdien til totalkonsentrasjonen av alle isomere.

3 Ferskvann innbefatter elver, innsjøer og sterkt modifiserte ferskvannsforekomster.

4 Den maksimalt tillatte verdien. Der hvor denne verdien ikke er oppgitt er den gjennomsnittlige årlige verdien ansett til også å beskytte mot kortvarige utslipp av forbindelsen.

5 I gruppen av bromerte flammehemmere kalt polybromerte difenyletere inngår kongener med numrene 28, 47, 99, 100, 153 og 154. Kun Tetra, Penta, Hexa og Heptabromdifenyleter er inkludert som prioritert farlige stoffer (henholdsvis CAS-nr 40088-47-9, 32534-81-9, 36483-60-0, 68928-80-3).

6 For kadmium og kadmiumforbindelser er miljøkvalitetsstandardene avhengig av vannets hardhet. Miljøkvalitetsstandardene er derfor delt inn i fem klasser (klasse 1: < 40 mg $CaCO_3$ /l, klasse 2: 40 til < 50 mg $CaCO_3$ /l, klasse 3: 50 til < 100 mg $CaCO_3$ /l, klasse 4: 100 til < 200 mg $CaCO_3$ /l og klasse 5: ≥ 200 mg $CaCO_3$ /l).

7 Det er ikke gitt noen standard på hvilke av stoffene i denne gruppen det skal analyseres på. Det er det er derfor opp til laboratoriene å velge ut hvilke av klorparafinene som skal analyseres.

8 Miljøkvalitetsstandarden gjelder den biotilgjengelige konsentrasjonen av stoffet.

9 Nonylfenol (CAS 25154-52-3) inkludert isomerene 4-nonylfenol (CAS 104-40-5) og 4-nonylfenol (forgrenet) (CAS 84852-15-3).

10 Octylfenol (CAS 1806-26-4) inkludert isomer 4-(1,1',3,3'-tetrametylbutyl)-fenol (CAS 140-66-9).

11 For Polyaromatiske hydrokarboner (PAH) refererer miljøkvalitetsstandardene for årlig gjennomsnitt til konsentrasjonen av benzo(a)pyren. Benzo(a)pyren kan betraktes som en markør for de andre PAHene, og det er kun benzo(a)pyren som må overvåkes for å sammenligne med årlig gjennomsnitt.

12 Disse stoffene trer i kraft som prioriterte stoffer ved utgangen av 2018, og skal frem til den tid ikke telle med i evalueringen av kjemisk tilstand.

13 Utilstrekkelig datagrunnlag for å kunne sette maksimal verdi.

14 Dette omfatter følgende stoffer: 7 polyklorerte dibenzo-p-dioksiner (PCDDer): 2,3,7,8-T4CDD (CAS 1746-01-6), 1,2,3,7,8-P5CDD (CAS 40321-76-4), 1,2,3,4,7,8- H6CDD (CAS 39227-28-6), 1,2,3,6,7,8-H6CDD (CAS 57653-85-7), 1,2,3,7,8,9-H6CDD (CAS 19408-74-3), 1,2,3,4,6,7,8-H7CDD (CAS 35822-46-9), 1,2,3,4,6,7,8,9-O8CDD (CAS 3268-87-9) 10 polyklorerte dibenzofuraner (PCDFs): 2,3,7,8-T4CDF (CAS 51207-31-9), 1,2,3,7,8-P5CDF (CAS 57117-41-6), 2,3,4,7,8-P5CDF (CAS 57117-31-4), 1,2,3,4,7,8-H6CDF (CAS 70648-26-9), 1,2,3,6,7,8-H6CDF (CAS 57117-44-9), 1,2,3,7,8,9-H6CDF (CAS 72918- 21-9), 2,3,4,6,7,8-H6CDF (CAS 60851-34-5), 1,2,3,4,6,7,8-H7CDF (CAS 67562-39-4), 1,2,3,4,7,8,9-H7CDF (CAS 55673-89-7), 1,2,3,4,6,7,8,9-O8CDF (CAS 39001-02-0) 12 dioksin-lignende polyklorerte bifenyler (PCB-DL): 3,3',4,4'-T4CB (PCB 77, CAS 32598-13-3), 3,3',4',5-T4CB (PCB 81, CAS 70362- 50-4), 2,3,3',4,4'-P5CB (PCB 105, CAS 32598-14-4), 2,3,4,4',5-P5CB (PCB 114, CAS 74472-37-0), 2,3',4,4',5-P5CB (PCB 118, CAS 31508-00-6), 2,3',4,4',5'-P5CB (PCB 123, CAS 65510-44-3), 3,3',4,4',5-P5CB (PCB 126, CAS 57465-28-8), 2,3,3',4,4',5-H6CB (PCB 156, CAS 38380-08-4), 2,3,3',4,4',5'-H6CB (PCB 157, CAS 69782-90-7), 2,3',4,4',5,5'-H6CB (PCB 167, CAS 52663-72-6), 3,3',4,4',5,5'-H6CB (PCB 169, CAS 32774-16-6), 2,3,3',4,4',5,5'-H7CB (PCB 189, CAS 39635-31-9).

15 CAS 52315-07-8 omfatter en blanding av isomerer av cypermethrin; alpha-cypermethrin (CAS 67375-30-8), beta-cypermethrin (CAS 65731-84-2), theta-cypermethrin (CAS 71697-59-1) og zeta-cypermethrin (52315-07-8).

16 Dette omfatter 1,3,5,7,9,11-Heksabromcyclododekan (CAS 25637-99-4), 1,2,5,6,9,10-Heksabromcyclododekan (CAS 3194-55-6), α-Heksabromcyclododekan (CAS 134237-50-6), ß-Heksabromcyclododekan (CAS 134237-51-7) og γ- Heksabromcyclododekan (CAS 134237-52-8).

A Prioritert farlige stoffer

1.2 Miljøkvalitetsstandarder for prioriterte stoffer og prioritert farlige stoffer i organismer

Miljøkvalitetsstandarder i organismer er angitt i µg/kg våtvekt.

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i organismer[2]
1	Antracen[A]	120-12-7	2400
2	Bromerte difenyletere[A]	32534-81-9	0,0085
3	Kortkjedete klorparafiner (C10-13)[A]	85535-84-8	6000
4	Di-(2-etylheksyl)ftalat (DEHP)[A]	117-81-7	2900
5	Endosulfan[A]	115-29-7	370
6	Fluoranten	206-44-0	30
7	Heksaklorbenzen[A]	118-74-1	10
8	Heksaklorbutadien[A]	87-68-3	55
9	Heksaklor- sykloheksan[A]	608-73-1	61
10	Kvikksølv og kvikksølvforbindelser[A]	7439-97-6	20
11	Naftalen	91-20-3	2400
12	Nonylfenol (4-nonylfenol)[A]	84852-15-3	3000
13	Oktylfenol 4-(1,1,3,3-tetrametylbutyl)fenol	140-66-9	0,004
14	Pentaklorbenzen[A]	608-93-5	50
15	Pentaklorfenol	87-86-5	180
16	PAH		
	Benzo(a)pyren	50-32-8	5
	Benzo(b)fluoranten	205-99-2	Se fotnote 4.
	Benzo(k)fluoranten	207-08-9	Se fotnote 4.
	Benzo(g,h,i)perylen	191-24-2	Se fotnote 4.
	Indeno(1,2,3-cd)pyren	193-39-5	Se fotnote 4.
17	Tributyltinnforbindelser (tributyltinn kation)[A]	36643-28-4	150
18	Triklorobenzener	12002-48-1	490

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i organismer[2]
19	Dicofol	115-32-2	33
20	Perfluoroktylsulfonat og dets derivater (PFOS)[A]	1763-21-1	9,1
21	Dioksin og dioksinlignende forbindelser[A]	Se fotnote 14 i del A i dette vedlegg.	Sum av PCDD+PCDF+PVB-DL 0,0065 µg/kg TEQ[5]
22	Heksabromsyklododekan (HBCDD)[A]	Se fotnote 16 i del A i dette vedlegg.	167
23	Heptaklor og heptaklorepoksid[A]	76-44-8/1024-57-3	$6{,}7x10^{-3}$

1 CAS- Chemical Abstracs service.

2 Miljøkvalitetsstandardene gjelder for fisk både i ferskvann og marine områder. Alternativ taksa eller matriks kan benyttes dersom miljøkvalitetsstandarden gir samme beskyttelsesnivå. For fluoranten (stoff nr. 6) og PAH (stoff nr. 16) gjelder miljøkvalitetsstandarden for krepsdyr og bløtdyr. Overvåking av fluoranten og PAH i fisk er ikke hensiktsmessig for å evaluere kjemisk tilstand. For dioksiner og dioksinlignende forbindelser (stoff nr. 21) gjelder miljøkvalitetsstandarden i fisk, krepsdyr og bløtdyr.

3 For Polyaromatiske hydrokarboner (PAH) refererer miljøkvalitetsstandardene i organismer til konsentrasjonen av benzo(a)pyren. Benzo(a)pyren kan betraktes som en markør for de andre PAHene, og det er kun benzo(a)pyren som må overvåkes for å sammenligne med EQS i organismer.

4 PCDD: polyklorerte dibenzo-p-dioksiner; PCDF: polyklorerte dibenzofuraner; PCB-DL: dioksinlignende polyklorerte bifenyler TEQ: toksisitetsekvivalenter i følge Verdens helseorganisasjon 2005 Toxic Equivalent Factors

A Prioritert farlige stoffer

1.3 Miljøkvalitetsstandarder for prioriterte stoffer og prioritert farlige stoffer i sediment

Miljøkvalitetsstandarder i sediment er angitt i mg/kg tørrstoff.

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i sediment (kystvann) [2]	Miljøkvalitetsstandard i sediment (ferskvann)[2]
1	Alaklor	15972-60-8	0,0003	
2	Antracen[A]	120-12-7	0,0046	
3	Bromerte difenyletere[A]	32534-81-9	0,062	0,31
4	Kadmium og kadmiumforbindelser[A]	7440-43-9	2,5	
5	C 10-13 kloralkaner[A]	85535-84-8	0,8	
6	Klorfenvifos	470-90-6	0,0005	

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i sediment (kystvann) [2]	Miljøkvalitetsstandard i sediment (ferskvann)[2]
7	Klorpyrifos	2921-88-2	0,0013	
8	Di-(2-etylheksyl)ftalat (DEHP)[A]	117-81-7	10	
9	Endosulfan[A]	115-29-7	0,00007	
10	Fluoranten	206-44-0	0,40	
11	Heksaklorbensen[A]	118-74-1	0,017	
12	Heksaklorbutadien[A]	87-68-3	0,049	
13	Heksaklor- sykloheksan[A]	608-73-1	0,000074	0,00074
14	Bly og blyforbindelser	7439-92-1	150	66
15	Kvikksølv og kvikksølvforbindelser[A]	7439-97-6	0,52	
16	Naftalen	91-20-3	0,027	
17	Nikkel og nikkelforbindelser	7440-02-0	42	
18	Nonylfenol[A]	84852-15-3	0,016	
19	Oktylfenol	140-66-9	0,0003	0,003
20	Pentaklorbenzen[A]	608-93-5	0,4	
21	Pentaklorfenol	87-86-5	0,014	
22	PAH[A]			
	Benzo(a)pyren	50-32-8	0,18	
	Benzo(b)fluoranten	205-99-2	0,14	
	Benzo(k)fluoranten	207-08-9	0,14	
	Benzo(g,h,i)perylen	191-24-2	0,084	
	Ideno(1,2,3-cd)pyren	193-39-5	0,063	
23	Tributyltinn forbindelser (tributyltinn kation)[A]	36643-28-4	0,000002	
24	Triklorbenzener	12002-48-1	0,0056	
25	Trifluralin[A]	1582-09-8	1,6	
26	Perfluoroktylsulfonat og dets derivater (PFOS)[A]	1763-23-1	0,00023	0,0023
27	Dioksin og dioksinlignende PCB[A]	Se fotnote 14 i tabell A i dette vedlegg.	8,6 x 10^{-7} TEQ	

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i sediment (kystvann) [2]	Miljøkvalitetsstandard i sediment (ferskvann)[2]
28	Heksabromsyklododekan (HBCDD)[A]	Se fotnote 16 i tabell A i dette vedlegg.	0,034	0,17

1 CAS- Chemical Abstracs service.

2 Miljøkvalitetsstandarder i sediment er ikke absolutte. Ved overskridelser av miljøkvalitetsstandarder i sediment bør stedsspesifikke undersøkelser og risikovurderinger gjennomføres.

A Prioritert farlige stoffer

1.4 Miljøkvalitetsstandarder for andre EU-utvalgte stoffer i vann.

Miljøkvalitetsstandarder i vann er angitt i µg/l.

Nr.	Navn på substans	CAS-nr.[1]	Årlig gjennomsnitt[2] for ferskvann[3]	Årlig gjennomsnitt for[2] for kystvann	Maksimal verdi[4] for ferskvann[3]	Maksimal verdi[4] for kystvann
1	DDT totalt [5]	Ikke relevant	0,025	0,025	Ikke oppgitt	Ikke oppgitt
	para-para-DDT	50-29-3	0,01	0,01	Ikke oppgitt	Ikke oppgitt
2	Aldrin	309-00-2	$\Sigma = 0{,}01$	$\Sigma = 0{,}005$	Ikke oppgitt	Ikke oppgitt
3	Dieldrin	60-57-1	$\Sigma = 0{,}01$	$\Sigma = 0{,}005$	Ikke oppgitt	Ikke oppgitt
4	Endrin	72-20-8	$\Sigma = 0{,}01$	$\Sigma = 0{,}005$	Ikke oppgitt	Ikke oppgitt
5	Isodrin	465-73-6	$\Sigma = 0{,}01$	$\Sigma = 0{,}005$	Ikke oppgitt	Ikke oppgitt
6	Karbontetraklorid	56-23-5	12	12	Ikke oppgitt	Ikke oppgitt
7	Tetrakloretylen	127-18-4	10	10	Ikke oppgitt	Ikke oppgitt
8	Trikloretylen	79-01-6	10	10	Ikke oppgitt	Ikke oppgitt

1 CAS- Chemical Abstracs service.
2 Den gjennomsnittlige årlige verdien. Hvis ikke annet er oppgitt svarer denne verdien til totalkonsentrasjonen av alle isomere.
3 Ferskvann innbefatter elver, innsjøer og sterkt modifiserte ferskvannsforekomster.
4 Den maksimalt tillatte verdien. Der hvor denne verdien ikke er oppgitt er den gjennomsnittlige årlige verdien ansett til også å beskytte mot kortvarige utslipp av forbindelsen.
5 DDT total består av summen av isomerene 1,1,1-trikloro-2,2 bis (p-klorofenyl) etane (CAS nummer 50-29-3); 1,1,1-trikloro-2 (o-klorofenyl)-2-(p-klorofenyl) etane (CAS nummer 789-02-6); 1,1-dikloro-2,2 bis (p-klorofenyl) etylen (CAS nummer 72-55-9); og 1,1-dikloro-2,2 bis (p-klorofenyl) etan (CAS nummer 72-54-8).

1.5 Miljøkvalitetsstandarder for andre EU-utvalgte stoffer i organismer og sediment

Miljøkvalitetsstandarder i sediment er angitt i mg/kg tørrstoff.

Nr	Navn på substans	CAS-nr.[1]	Miljøkvalitetsstandard i organismer (µg/kg våtvekt)	Miljøkvalitetsstandard i sediment (mg/kg tørrvekt)
1	DDT totalt [2]	Ikke relevant	609	0,015
	para-para-DDT	50-29-3		0,006

1 CAS- Chemical Abstracs service.

2 DDT total består av summen av isomerene 1,1,1-trikloro-2,2 bis (p-klorofenyl) etane (CAS nummer 50-29-3); 1,1,1-trikloro-2 (o-klorofenyl)-2-(p-klorofenyl) etane (CAS nummer 789-02-6); 1,1-dikloro-2,2 bis (p-klorofenyl) etylen (CAS nummer 72-55-9); og 1,1-dikloro-2,2 bis (p-klorofenyl) etan (CAS nummer 72-54-8).

1.6 Miljøkvalitetsstandarder for vannregionspesifikke stoffer i vann, sediment og biota

Nr	Navn på Navn substans	*CAS-nr.[1]*	Ferskvann		Kystvann		Sediment	Biota
			Årlig gjennomsnitt[2] for ferskvann[3] µg/l	*Maksimal verdi[4] for ferskvann[3]l µg/l*	*Årlig gjennomsnitt[2] for kystvann µg/l*	*Maksimal verdi[4] for kystvann µg/l*	*EQSsed mg/kg TS*	*QS-biota,hh µg/kg biota*
1	Bisfenol A	80-05-7	1.5	11	0.15	11	0.0011	
2	TBBPA (Tetrabromobisfenol A)	79-94-7	0.254	0.9	0.254	0.9	0.108	
3	Dekametyl syklopentasiloksan (D5)	541-02-6	1.7	17	0.17	1.7	0.044	15217
4	Klorparafiner (mellomkjedete)	85535-85-9	0.05		0.05		4.6	170
5	PFOA	3825-26-1. flere	9.1	Ikke oppgitt	9.1	Ikke oppgitt	0.071	91.3
6	Triklosan	3380-34-5	0.1	0.28	0.1	0.28	0.009	15217
7	TCEP (tris(2-kloretyl)fosfat)	*115-96-8*	65	510	6.5	510	0.0716	7304

Nr	Navn på Navn substans	*CAS-nr.*[1]	Ferskvann		Kystvann		Sediment	Biota
8	Dodecylfenol med isomere	*121158-58-5, 27193-86-8*	0.04	0.17	0.004	0.017	0.0044	
9	Diflubenzuron	35367-38-5	0.004	0.1	0.004	0.1	0.000184	730
10	Teflubenzuron	83121-18-0	0.0025	0.12	0.0025	0.012	0.0000004	609
11	Trifenyltin	*892-20-6, 900-95-8, 76-87-9, 639-58-7*	0.0019	0.035	0.0019	0.035	3.61E-05	152 (med 100% TDI)
12	PCB7	1336-36-3	2.4E-06		2.4E-06		0.0041	1
13	Kobber	7440-50-8	7.8	7.8	2.6	2.6	84	
14	Sink	7440-66-6	11	11	3.38	6	139	
15	PAH							
	Acenaftylen	208-96-8	1.28	33	1.28	3.3	0.033	
	Acenaften	83-32-9	3.8	3.8	3.8	3.8	0.10	
	Fluoren	86-73-7	1.5	33.9	1.5	6.8	0.15	
	Fenantren	85-01-8	0.5	6.7	0.5	6.7	0.78	
	Pyren	129-00-0	0.023		0.023		0.084	
	Benzo(a) antracen	56-55-3	0.012	0.018	0.012	0.018	0.06	304
	Krysen	218-01-9	0.07	0.07	0.07	0.07	0.28	
	Dibenso(ah)antracen	53-70-3	0.0006	0.014	0.0006	0.014	0.027	
16	Arsen	7440-38-2	0.5	8.5	0.6	8.5	18	
17	Krom	7440-47-3 (Cr metall)*;*	3.4	3.4	3.4	35.8	660	

1 CAS- Chemical Abstracs service.
2 Den gjennomsnittlige årlige verdien. Hvis ikke annet er oppgitt svarer denne verdien til totalkonsentrasjonen av alle isomere.
3 Ferskvann innbefatter elver, innsjøer og sterkt modifiserte ferskvannsforekomster.
4 Den maksimalt tillatte verdien. Der hvor denne verdien ikke er oppgitt er den gjennomsnittlige årlige verdien ansett til også å beskytte mot kortvarige utslipp av forbindelsen.

2. Tilstandsklasser for Prioriterte- og vannregionspesifikke stoffer i ferskvann, kystvann og sediment

2.1 Tilstandsklasser for ferskvann (µg/l)

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
		Bakgrunn	AA-EQS	MAC-EQS		Omfattende akutt tox eff.
1	Kadmium	*0.003*	*Fotnote 1*	*Fotnote 2*	*Fotnote 3*	*Fotnote 3*
2	Bly	*0.02*	1.2	14	57	> 57
3	Nikkel	0.5	*4*	34	67	> 67
4	Kvikksølv	0.001	0.047	0.07	*0.14*	*> 0.14*
5	TBT		0.0002	0.0015	0.003	> 0.003
6	Bromerte difenyletere		4.9E-08	0.14	*0.28*	*> 0.28*
7	Heksaklorbensen		*0.013* [4)]	0.05	0.47	> 0.47
8	Heksaklorbutadien		*0.003*	0.6	5.9	> 5.9
9	Heksaklorsykloheksan		0.02	0.04	*0.26*	*> 0.26*
10	C10-13 kloralkaner		0.4	1.4	2.8	> 2.8
11	Pentaklorbenzen		*0.007*	2	10	> 10
12	Pentaklorfenol		0.4	1	2	> 2
13	Triklorbenzen		0.4	*50*	*100*	*> 100*
14	Naftalen	*0.00066*	2	130	650	> 650
14	Antracen	*0.004*	0.1	0.1	1	> 1
14	Fluroanten	*0.00029*	*0.0063*	0.12	0.6	> 0.6
14	Benzo(b)fluoranten	*0.000017*	0.017	0.017	*1.28*	*> 1.28*
14	Benzo(k)fluoranten	*0.000017*	0.017	0.017	*0.93*	*> 0.93*

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
14	Benzo(a)pyren	*0.000005*	*0.00017*	0.27	*1.54*	*> 1.54*
14	Indeno(1,2,3-cd)pyren	*0.000017*	0.0027	0.0027	*0.1*	*> 0.1*
14	Benzo(g,h,i)perylen	*0.000011*	0.0082	*0.0082*	*0.14*	*> 0.14*
15	Nonylfenol		0.3	2	4	> 4
16	Oktylfenol		0.1	0.27	1.3	> 1.3
17	Alaklor		0.3	*0.7*	*1.3*	*> 1.3*
18	Klorfenvinfos		0.1	0.3	0.63	> 0.63
19	Klorpyrifos		*0.03*	*0.1*	*0.3*	*> 0.3*
20	Endosulfan		0.005	*0.01*	0.13	> 0.13
21	Trifluralin		0.03	*0.88*	*8.8*	*> 8.8*
22	DEHP		1.3	-	-	-
23	HBCDD	*0 (LOD 0.001)*	0.0016	0.5	*5.2*	*> 5.2*
24	PFOS		0.00065	*36*		
25	Dioksiner		1.9E-08			
26	DDT (p,p'-DDT)		*0.025 (0.01)*	*0.0265 (0.0265)*	*0.265*	*> 0.265*
27	Bisfenol A	*0*	*1.5*	*11*	*110*	*> 110*
28	TBBPA		*0.25*	*0.9*	*9*	*> 9*
29	D5		1.7	17	-	-
30	Klorparafiner (mellomkjedete)		*0.05*	0.59	1.2	> 1.2
31	PFOA		*9.1*			
32	Triklosan		*0.1*	*0.28*	*2.8*	*> 2.8*
33	TCEP		65	*510*	*5100*	*> 5100*
34	Dodecylfenol med isomere		0.04	0.17	*1.7*	*> 1.7*
35	Diflubenzuron		*0.004*	*0.1*	*1*	*> 1*
36	Teflubenzuron		*0.0025*	0.12	*1.2*	*> 1.2*
37	Trifenyltin		*0.0019*	*0.035*	*0.35*	*> 0.351*
38	PCB7		-	-	-	-

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
39	Kobber	0.3	7.8	7.8	*15.6*	*> 15.6*
40	Sink	1.5	11	11	60	> 60
41	PAH					
	Acenaftylen	*0.00001*	1.3	*33*	330	> 330
	Acenaften	*0.000034*	3.8	*3.8*	*382*	*> 382*
	Fluoren	*0.00019*	*1.5*	*34*	*339*	*> 339*
	Fenantren	*0.00025*	*0.51*	*6.7*	*67*	*> 67*
	Pyren	*0.000053*	0.023	0.023	*0.23*	*> 0.23*
	Benzo(a)antracen	*0.000006*	0.012	0.018	1.8	> 1.8
	Krysen	*0.000056*	0.07	0.07	0.7	> 0.7
	Dibenso(ah)antracen	*0.000001*	*0.00061*	*0.014*	*0.14*	*> 0.14*
42	Arsen	0.15	*0.5*	8.5	85	> 85
43	Krom	*0.1*	3.4	3.4	3.4	> 3.4

1) Klasse II Cd verdier avhengig av vannets hardhet: ≤ 0.08 (< 40 mg $CaCO_3$/L); 0.08 (40 - <50 mg $CaCO_3$/L); 0.09 (50 - <100 mg $CaCO_3$/L); 0.15 (100 -<200 mg $CaCO_3$/L); 0.25 (≥200 mg $CaCO_3$/L)
2) Klasse III Cd verdier avhengig av vannets hardhet:≤ 0.45 (< 40 mg $CaCO_3$/L); 0.45 (40 - <50 mg $CaCO_3$/L); 0.60 (50 - <100 mg $CaCO_3$/L); 0.9 (100 -<200 mg $CaCO_3$/L); 1.5 (≥200 mg $CaCO_3$/L)
3) Klasse IV Cd verdier avhengig av vannets hardhet:≤ 4.5 (< 40 mg $CaCO_3$/L); 4.5 (40 - <50 mg $CaCO_3$/L); 6.0 (50 - <100 mg $CaCO_3$/L); 9.0 (100 -<200 mg $CaCO_3$/L); 15 (≥200 mg $CaCO_3$/L). Verdier over tilhøre til klasse V.
4) HCB AA-EQS basert på human helse er 0.0002 µg/L, men BCF er usikker

2.2 Tilstandsklasser for kystvann (µg/l)

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
		Bakgrunn	AA-EQS	MAC-EQS		Omfattende akutt tox eff.
1	Kadmium	0.03	0.2	*Fotnote 1*	*Fotnote 2*	*Fotnote 2*
2	Bly	*0.02*	1.3	14	57	> 57
3	Nikkel	0.5	8.6	34	67	> 67
4	Kvikksølv	0.001	0.047	0.07	*0.14*	*> 0.14*

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
5	TBT		0.0002	0.0015	0.003	> 0.003
6	Bromerte difenyletere		2.4E-09	0.014	*0.28*	*> 0.28*
7	Heksaklorbensen		*0.013* [3)]	0.05	0.47	> 0.47
8	Heksaklorbutadien		*0.003*	0.6	5.9	> 5.9
9	Heksaklorsykloheksan		0.002	0.02	*0.26*	*> 0.26*
10	C10-13 kloralkaner		0.4	1.4	2.8	> 2.8
11	Pentaklorbenzen		*0.0007*	2	10	> 10
12	Pentaklorfenol		*0.4*	1	2	> 2
13	Triklorbenzen		0.4	*50*	*100*	*> 100*
14	Naftalen	*0.00066*	2	130	650	> 650
14	Antracen	*0.004*	0.1	0.1	1	> 1
14	Fluroanten	*0.00029*	*0.0063*	0.12	0.6	> 0.6
14	Benzo(b)fluoranten	*0.000017*	0.017	*0.017*	*1.28*	*> 1.28*
14	Benzo(k)fluoranten	*0.000017*	0.017	*0.017*	*0.93*	*> 0.93*
14	Benzo(a)pyren	*0.000005*	*0.00017*	*0.027*	*1.5*	*> 1.5*
14	Indeno(1,2,3-cd)pyren	*0.000017*	0.0027	*0.0027*	*0.1*	*> 0.1*
14	Benzo(g,h,i)perylen	*0.000011*	*0.00082*	*0.00082*	*0.14*	*> 0.14*
15	Nonylfenol		0.3	2	4	> 4
16	Oktylfenol		0.01	0.27	1.3	> 1.3
17	Alaklor		0.3	*0.7*	*1.3*	*> 1.3*
18	Klorfenvinfos		0.1	0.3	0.63	> 0.63
19	Klorpyrifos		*0.03*	*0.1*	*0.3*	*> 0.3*
20	Endosulfan		0.0005	*0.004*	*0.04*	*> 0.04*
21	Trifluralin		0.03	*0.88*	*8.8*	*> 8.8*
22	DEHP		1.3	-	-	-
23	HBCDD	*0 (LOD 0.001)*	0.0008	0.05	*5.2*	*> 5.2*
24	PFOS		0.00013	*7.2*		
25	Dioksiner		1.9E-09			>

Nr	Navn på Navn substans	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
26	DDT (p,p'-DDT(		*0.025 (0.01)*	*0.0265 (0.0265)*	*0.265*	*> 0.265*
27	Bisfenol A		0.15	*11*	*110*	*> 110*
28	TBBPA	*0*	*0.25*	0.9	*9*	*> 9*
29	D5		0.17	1.7	*17*	*> 17*
30	Klorparafiner (mellomkjedete)		*0.05*	*0.059*	1.2	> 1.2
31	PFOA		*9.1*			
32	Triklosan		*0.1*	*0.28*	*2.8*	*> 2.8*
33	TCEP		6.5	*510*	*5100*	*> 5100*
34	Dodecylfenol med isomere		0.004	0.017	*0.17*	*> 0.17*
35	Diflubenzuron		*0.004*	*0.1*	*1*	*> 1*
36	Teflubenzuron		*0.0025*	0.012	1.2	> 1.2
37	Trifenyltin		*0.0019*	*0.035*	*0.35*	*> 0.35*
38	PCB7		-	-	-	-
39	Kobber	0.3	2.6	2.6	5.2	> 5.2
40	Sink	1.5	3.4	6	60	> 60
41	PAH					
41	Acenaftylen	*0.00001*	1.3	3.3	330	> 330
41	Acenaften	*0.000034*	3.8	*3.8*	*382*	*> 382*
41	Fluoren	*0.00019*	*1.5*	*6.8*	*339*	*> 339*
41	Fenantren	*0.00025*	*0.51*	*6.7*	*67*	*> 67*
41	Pyren	*0.000053*	0.023	0.023	*0.23*	*> 0.23*
41	Benzo(a)antracen	*0.000006*	0.012	0.018	1.8	> 1.8
41	Krysen	*0.000056*	0.07	0.07	0.7	> 0.7
41	Dibenso(ah)antracen	*0.000001*	*0.0006*	*0.014*	*0.14*	*> 0.14*
42	Arsen	0.15	*0.6*	8.5	85	> 85
43	Krom	*0.1*	3.4	36	358	> 358

1) Klasse III Cd verdier avhengig av vannets hardhet: ≤ 0.45 (< 40 mg $CaCO_3$/L); 0.45 (40 - <50 mg $CaCO_3$/L); 0.60 (50 - <100 mg $CaCO_3$/L); 0.9 (100 -<200 mg $CaCO_3$/L); 1.5 (≥200 mg $CaCO_3$/L)

2) Klasse IV Cd verdier avhengig av vannets hardhet:≤ 4.5 (< 40 mg $CaCO_3$/L); 4.5 (40 - <50 mg $CaCO_3$/L); 6.0 (50 - <100 mg $CaCO_3$/L); 9 (100 -<200 mg $CaCO_3$/L); 15 (≥200 mg $CaCO_3$/L). Verdier over tilhøre til klasse V.
3) HCB AA-EQS basert på human helse er 0.0002 µg/L, men BCF er usikker

2.3 Tilstandsklasser for sediment

Nr	Navn på Navn substans	Enhet	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
			Bakgrunn	AA-EQS	MAC-EQS		Omfattende akutt tox eff.
1	Kadmium	mg/kg TS	0.2	2.5 (Ferskvann : 1.5)	16	157	> 157
2	Bly	mg/kg TS	25	150 (Ferskvann :66)	1480	2000	2000-2500
3	Nikkel	mg/kg TS	30	42	271	533	> 533
4	Kvikksølv	mg/kg TS	0.05	0.52	0.75	1.45	> 1.45
5	TBT	µg/kg TS		0.002	0.016	0.032	> 0.032
6	Bromerte difenyletere	µg/kg TS		62 (Ferskvann : 310)	79 (Ferskvann:790)	1580	> 1580
7	Heksaklorbensen	µg/kg TS	0	17	61	610	> 610
8	Heksaklorbutadien	µg/kg TS	0	49	66	660	> 660
9	Heksaklorsykloheksan	µg/kg TS	0	0.074 (Ferskvann : 0.74)	0.74 (Ferskvann: 1.5)	9.8	> 9.8
10	C10-13 kloralkaner	µg/kg TS		800	2800	5600	> 5600
11	Pentaklorbenzen	µg/kg TS	0	400	800	4000	> 4000
12	Pentaklorfenol	µg/kg TS	0	14	34	68	> 68
13	Triklorbenzen	µg/kg TS	0	5.6	700	1400	> 1400
14	Naftalen	µg/kg TS	2	27	1754	8769	> 8769
14	Antracen	µg/kg TS	1.2	4.6	30	295	> 295
14	Fluroanten	µg/kg TS	8	400	400	2000	> 2000

Nr	Navn på Navn substans	Enhet	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
14	Benzo(b)fluoranten	µg/kg TS	90	140	140	10600	> 10600
14	Benzo(k)fluoranten	µg/kg TS	90	135	135	7400	> 7400
14	Benzo(a)pyren	µg/kg TS	6	183	230 (Ferskvann: 2300)	13100	> 13100
14	Indeno(1,2,3-cd)pyren	µg/kg TS	20	63	63	2300	> 2300
14	Benzo(g,h,i)perylen	µg/kg TS	18	84	84	1400	> 1400
15	Nonylfenol	µg/kg TS	0	16	107	214	> 214
16	Oktylfenol	µg/kg TS	0	0.27 (Ferskvann: 2.7)	7.3	36	> 36
17	Alaklor	µg/kg TS		0.3	0.78	1.5	> 1.5
18	Klorfenvinfos	µg/kg -ts		0.5	1.4	3.0	> 3.0
19	Klorpyrifos	µg/kg TS		1.3	4.44	13	> 13
20	Endosulfan	µg/kg TS		0.073	0.6	6	> 6
21	Trifluralin	mg/kg TS		1.6	1.6	16	> 16
22	DEHP	mg/kg TS	0	10	100	1200	> 1200
23	HBCDD	µg/kg TS	0	34 (Ferskvann: 172)	34 (Ferskvann: 229)	2382	> 2382
24	PFOS	µg/kg TS		0.23 (Ferskvann: 2.3)	72 (Fesrskvann: 360)		
25	Dioksiner	µg/kg TEQ TS		8.6E-04	3.6E-03 TEQ (Ferskvann: 8.8 E-03 TEQ)	0.5	> 0.5
26	DDT	µg/kg TS		15 (p,p'-DDT: 6)	165	1647	> 1647
27	Bisfenol A	µg/kg TS		1.1 (Ferskvann: 11)	79	790	> 790
28	TBBPA	µg/kg TS		108	383	3830	> 3830

Nr	Navn på Navn substans	Enhet	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
29	D5	mg/kg TS		0.044 (Ferskvann :0. 44)	2.6	26	> 26
30	Klorparafiner (mellomkjedete)	mg/kg TS		4.6	27	54	> 54
31	PFOA	µg/kg TS		71 (Ferskvann : 713)			
32	Triklosan	µg/kg TS		9.3	26	260	> 260
33	TCEP	µg/kg TS		72	562	5620	> 5620
34	Dodecylfenol med isomere	µg/kg TS		4.4	18.7	187	> 187
35	Diflubenzuron	µg/kg TS		0.2	4.6	46	> 46
36	Teflubenzuron	µg/kg TS		0.0004	0.02 (Ferskvann: 0.2)	2	> 2
37	Trifenyltin	µg/kg TS		0.036	0.67	6.7	> 6.7
38	PCB7	µg/kg TS	-	4.1	43	430	> 430
39	Kobber	mg/kg TS	20	84 (fv:210)	84 (Ferskvann:210)	147 (Ferskvann: 400)	> 147 (Ferskvann: 400)
40	Sink	mg/kg TS	90	139	750	6690	> 6690
41	PAH						
41	Acenaftylen	µg/kg TS	1.6	33	85	8500	> 8500
41	Acenaften	µg/kg TS	2.4	96	195	19500	> 19500
41	Fluoren	µg/kg TS	6.8	150	694	34700	> 34700
41	Fenantren	µg/kg TS	6.8	780	2500	25000	> 25000
41	Pyren	µg/kg TS	5.2	84	840	8400	> 8400
41	Benzo(a) antracen	µg/kg TS	3.6	60	501	50100	> 50100
41	Krysen	µg/kg TS	4.4	280	280	2800	> 2800
41	Dibenso(ah)antracen	µg/kg TS	12	27	273	2730	> 2730
42	Arsen	mg/kg TS	15	18	71	580	> 580

Nr	Navn på Navn substans	Enhet	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
43	Krom	mg/kg TS	60	660 (Ferskvann: 112)	6000 (Ferskvann: 112)	15500 (Ferskvann: 112)	15500-25000 (Ferskvann: 112)

a) Hardhet: < 40 mg $CaCO_3$/L

Miljødirektoratet
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Mjødirektoratet jobber for et rent og rikt miljø. Våre hovedoppgaver er å redusere klimagassutslipp, forvalte norsk natur og hindre forurensning.

Vi er et statlig forvaltningsorgan underlagt Klima- og miljødepartementet og har mer enn 700 ansatte ved våre to kontorer i Trondheim og Oslo, og ved Statens naturoppsyn (SNO) sine mer enn 60 lokalkontor.

Vi gjennomfører og gir råd om utvikling av klima- og miljøpolitikken. Vi er faglig uavhengig. Det innebærer at vi opptrer selvstendig i enkeltsaker vi avgjør, når vi formidler kunnskap eller gir råd. Samtidig er vi underlagt politisk styring.
Våre viktigste funksjoner er at vi skaffer og formidler miljøinformasjon, utøver og iverksetter forvaltningsmyndighet, styrer og veileder regionalt og kommunalt nivå, gir faglige råd og deltar i internasjonalt miljøarbeid.

C Fuel oil analysis

Operational FQT Report : 21-Jul-2016
CLIPPER HARALD (9173068)

Summary

Based on the analysis results, the fuel is expected to perform satisfactorily provided adequate onboard fuel treatment

Sample Number	ROT1625343	**Customer**	SOLVANG ASA
Product Type	(HFO)	**Seal Data**	VPS, INTACT, 0173405
Bunker Port	OFF SKAGEN		
Bunker Date	15-Jul-2016	**Related Samples**	
Sampling Point	SHIP MANIFOLD		0173406
Sampling Method	CONTINUOUS DRIP		0173407
			0173408
Sent From	STAVANGER	**MARPOL**	257035
Date Sent	19-Jul-2016		
Arrived at Lab	20-Jul-2016		
Supplier	TOPOIL (SWEDEN)		
Loaded From	AALBORG		
Quantity per C.Eng.	420		

Receipt Data

Source Of Data	B.D.N.		**Sulfur**	2.60	% m/m
Density @ 15°C	990.3	kg/m³	**Volume @ 15°C**	425.536	m³
Viscosity @ 50°C	NOT STATED	mm²/s	**Quantity**	421.408	MT

Fuel Quality

Current	Trend	Parameter	**OFF SKAGEN 15-Jul-2016**	ROT1619916 SKAW 04-Jun-2016	ROT1615564 OFF GOTHENBURG 06-May-2016	ROT1610533 OFF SKAW 22-Mar-2016	Unit
		Density @ 15°C	**990.5**	985.2	990.7	990.4	kg/m³
		Viscosity @ 50°C	**373.5**	381.4	365.7	371.2	mm²/s
		Water	**0.10**	0.12	0.10	0.15	% V/V
		Micro Carbon Residue	**16.52**	14.29	15.53	15.93	% m/m
		Sulfur	**2.59**	2.53	2.58	2.56	% m/m
		Total Sediment Potential	**0.02**	0.05	0.03	0.02	% m/m
		Ash	**0.06**	0.06	0.06	0.06	% m/m
		Vanadium	**208**	179	191	172	mg/kg
		Sodium	**31**	27	32	28	mg/kg
		Iron	**51**	53	42	35	mg/kg
		Nickel	**53**	44	45	47	mg/kg
		Calcium	**2**	3	3	3	mg/kg
		Magnesium	**LT 1**	LT 1	LT 1	LT 1	mg/kg
		Zinc	**2**	2	2	2	mg/kg
		Phosphorus	**LT 1**	4	LT 1	LT 1	mg/kg
		Potassium	**LT 1**	LT 1	LT 1	LT 1	mg/kg
		Pour Point	**LT 24**	LT 24	LT 24	LT 24	°C
		Flash Point	**GT 70.0**	64.0	GT 70.0	GT 70.0	°C
		Aluminium + Silicon	**17**	8	17	13	mg/kg
		CCAI (Ignition Quality)	**852**	846	852	852	-
	Reported problems with fuel			No	No	No	

Other Parameters

Parameter	Result	Unit
Acid Number	LT 0.1	mg KOH/g

Operational Advice :

	Approximate fuel temperatures: Injection: 145°C for 10 mm²/s 125°C for 15 mm²/s 115°C for 20 mm²/s 110°C for 25 mm²/s Transfer : 45°C

VPS Colour Code used :
Satisfactory Caution Use of fuel not recommended Fuel Trend

Note:
LT means Less Than, GT means Greater Than.
Quantity (Weight) is based on BDN Volume, VPS Density and
a weight factor of 1.1 kg/m³ (ASTM D1250-80 Table 56).

Best Regards,
On behalf of Veritas Petroleum Services BV
E.J.T. Westgeest
Technical Adviser

End of Report for CLIPPER HARALD

Reference to part(s) of this report which may lead to misinterpretation is prohibited.

For technical or operational advice or further information on this report please contact your nearest VPS office or contact us directly at Tel : +31 (0) 180 221100 Email : Tech.Rot@v-p-s.com