HYUNDAI HEAVY INDUSTRIES CO.,LTD.	**HiBallast™ Ballast Water Management System**

Document 3-3. Land-based Test Log

APPLICATION/PROJECT	Alternate Management System (AMS)
APPROVAL AUTHORITY	USCG
DOCUMENT NO.	HiB-03300-AMS
APPLICANT	Hyundai Heavy Industries Co., Ltd.
ISSUING PARTY	Engine & Machinery Research Institute / R&D Division

Rev.	Date	Reason for Issue	Prepared	Checked	Approved
0	25 Sep., 2012	Draft	T. J. Rhee	Y. G. Kim	K. N. Chung
1	25 Oct., 2012	Final	S. H. Yoon	Y. G. Kim	K. N. Chung
2					
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LAND BASED TEST

TITLE SEAWATER TEST 1

Obj. **FILTER + ELECTROLYSIS, SW 1**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.04.01	14:55	2010.04.01	13:15
END, BALLASTING	-	2010.04.01	16:10	2010.04.01	14:27
START, DEBALLASTING	-	2010.04.06	13:40	2010.04.06	11:46
END, DEBALLASTING	-	2010.04.06	14:40	2010.04.06	12:40

Test duration		
72	min	Treatment, B
75	min	Control, B
54	min	Treatment, DB
60	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	201	212
DOSAGE	mg/L	7.32	8.45	9.54
FILTER BACKFLUSHING (COUNT)	n/hr		60	
Electrolyzer Voltage	V		47.6	
Electrolyzer Current	A		133.7	
Water Temperature	℃	12.4	13	13
Electrolysis Unit Power Consumption	kW		6.4	
Electrolysis Unit Energy Consumption	kWh		7.7	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.04.01		0	8.45		
Day 0, after operation	mg/L	2010.04.01	14:50	0	7.07	0	
Day 1	mg/L	2010.04.02		1	5.57	0.23847	
Day 2	mg/L	2010.04.03		2	4.75		
Day 3	mg/L	2010.04.04		3	4.18		
Day 4	mg/L	2010.04.05		4	3.93		
Day 5, before neutralization	mg/L	2010.04.06		5	3.85	0.60779	0.122
Day 5, after neutralization	mg/L	2010.04.06			0.03		
Decay Constant	1/day	Temp.	13.16		0.12		

Chlorine demand, 20 min: 1.31 mg/L

8.38 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	521,000.0	378,000.0	2,433.3	0.3		6.0	99.9999	99.9988
> 10 ㎛ and < 50 ㎛	organisms/ml	1,722.3	1,873.3	280.0	0.0		0.0	100.0000	100.0000
Heterotrophs	cfu/ml	77,091.0	42,622.0	5,611.3	0.0		26.7	100.0000	99.9654
Coliform	cfu/ml	0.0	0.0	0.0	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	302.0	TNTC	11.3	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	250.0	TNTC	125.3	0.0		0.0	100.0000	100.0000
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	12.5	12.4	12.6	12.5	13.4	13.6	
pH	-	7.8	7.8	7.4	7.8	7.6	7.6	
ORP	mV	441.0	888.3	445.3	939.3	890.0	705.7	
Salinity (> 33 PSU)	PSU	35.7	35.7	35.9	35.8	35.9	35.8	
DO	mg/L	8.6	8.5	7.6	7.6	7.9	7.8	
Turbidity(NTU)	NTU	13.0	14.3	8.0	13.5	12.9	11.2	
TSS (> 1 mg/L)	mg/L	30.8	35.2	23.0	29.9		27.1	
DOC (> 1 mg/L)	mg/L	2.4	2.4	1.4	2.5	3.5	2.8	
POC (> 1 mg/L)	mg/L	1.9	1.8	0.4	1.9	2.2	1.6	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.04.16

LAND BASED TEST

TITLE SEAWATER TEST 2

Obj. **FILTER + ELECTROLYSIS, SW 2, By-products Analysis**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.04.08	15:05	2010.04.08	13:25
END, BALLASTING	-	2010.04.08	16:14	2010.04.08	14:38
START, DEBALLASTING	-	2010.04.13	13:22	2010.04.13	11:25
END, DEBALLASTING	-	2010.04.13	14:12	2010.04.13	12:19

Test duration		
73	min	Treatment, B
69	min	Control, B
54	min	Treatment, DB
50	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	192	200	207
DOSAGE	mg/L	4.64	8.5	9.96
FILTER BACKFLUSHING (COUNT)	n/hr		30	
Electrolyzer Voltage	V		48.5	
Electrolyzer Current	A		135.6	
Water Temperature	°C	12.1	12.45	12.8
Electrolysis Unit Power Consumption	kW		6.6	
Electrolysis Unit Energy Consumption	kWh		8	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.04.08		0	8.5		
Day 0, after operation	mg/L	2010.04.08	15:00	0	7.56	0	
Day 1	mg/L	2010.04.09		1	6.01	0.22945	
Day 2	mg/L	2010.04.10		2	5.46		
Day 3	mg/L	2010.04.11		3	5.05		
Day 4	mg/L	2010.04.12		4	4.58		
Day 5, before neutralization	mg/L	2010.04.13		5	4.09	0.61433	0.123
Day 5, after neutralization	mg/L	2010.04.13			0.05		
Decay Constant	1/day	Temp.	12.72		0.12		

Chlorine demand, 20 min: 1.6 mg/L

9.16 Injection Conc. (mg/L)

PERFORMANCE

Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	287,000.0	293,333.3	1,700.0	0.3		0.0	99.9999	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	1,411.7	1,233.7	265.6	0.0		0.3	100.0000	99.9764
Heterotrophs	cfu/ml	10,590.0	12,966.3	955.3	0.0		56.7	100.0000	99.4649
Coliform	cfu/ml	0.0	0.0	0.0	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	8.0	TNTC	0.0	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	165.0	124.3	16.3	0.0		0.0	100.0000	100.0000
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	°C	11.7	12.1	13.0	12.7	12.6	12.9	
pH	-	7.9	8.0	7.7	7.9	7.6	7.6	
ORP	mV	578.0	800.0	529.3	930.7	876.0	731.3	
Salinity (> 33 PSU)	PSU	35.6	35.5	35.4	35.5	35.3	35.4	
DO	mg/L	9.6	9.8	8.3	8.4	8.4	8.6	
Turbidity(NTU)	NTU	6.5	6.9	2.4	6.7	2.5	6.3	
TSS (> 1 mg/L)	mg/L	22.1	19.4	12.4	21.1		19.1	
DOC (> 1 mg/L)	mg/L	2.6	2.7	1.5	2.7	2.7	2.7	
POC (> 1 mg/L)	mg/L	1.2	1.7	0.5	1.2	0.7	1.8	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.04.23

LAND BASED TEST

TITLE SEAWATER TEST 3

Obj. **FILTER + ELECTROLYSIS, SW 3**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.04.15	13:20	2010.04.15	10:50
END, BALLASTING	-	2010.04.15	14:30	2010.04.15	12:03
START, DEBALLASTING	-	2010.04.20	13:34	2010.04.20	11:25
END, DEBALLASTING	-	2010.04.20	14:34	2010.04.20	12:16

Test duration		
73	min	Treatment, B
70	min	Control, B
51	min	Treatment, DB
60	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	192	200	207
DOSAGE	mg/L	8.9	9.5	9.915
FILTER BACKFLUSHING (COUNT)	n/hr		86	
Electrolyzer Voltage	V		48.9	
Electrolyzer Current	A		137	
Water Temperature	°C	11.7	12.05	12.4
Electrolysis Unit Power Consumption	kW		6.7	
Electrolysis Unit Energy Consumption	kWh		8.2	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.04.15		0	9.5		
Day 0, after operation	mg/L	2010.04.15	12:30	0	8.2	0	
Day 1	mg/L	2010.04.16		1	6.31	0.262	
Day 2	mg/L	2010.04.17		2	5.51		
Day 3	mg/L	2010.04.18		3	5.25		
Day 4	mg/L	2010.04.19		4	4.83		
Day 5, before neutralization	mg/L	2010.04.20		5	4.87	0.52104	0.104
Day 5, after neutralization	mg/L	2010.04.20			0.05		
Decay Constant	1/day	Temp.	12.70		0.1		

Chlorine demand, 20 min: 1.35 mg/L

9.55 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	569,000.0	472,333.3	3,633.3	0.0		0.0	100.0000	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	1,419.0	1,437.6	334.1	0.7		0.7	99.9530	99.9530
Heterotrophs	cfu/ml	9,591.0	11,111.0	1,933.0	1.0		6.7	99.9896	99.9305
Coliform	cfu/ml	0.0	15.7	32.7	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	130.0	TNTC	1.3	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	535.0	634.7	59.7	0.0		0.0	100.0000	100.0000
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	°C	11.4	11.4	13.0	11.3	13.1	13.7	
pH	-	8.0	8.0	7.8	7.9	8.0	7.8	
ORP	mV	557.0	795.7	624.3	964.0	906.0	719.3	
Salinity (> 33 PSU)	PSU	35.6	35.7	35.6	35.6	35.3	35.5	
DO	mg/L	8.9	9.4	8.3	8.6	8.4	8.5	
Turbidity(NTU)	NTU	9.4	8.7	3.5	8.8	4.0	9.1	
TSS (> 1 mg/L)	mg/L	28.1	21.6	15.5	25.7		24.9	
DOC (> 1 mg/L)	mg/L	2.4	2.3	1.3	2.5	2.8	2.7	
POC (> 1 mg/L)	mg/L	1.8	1.9	0.2	1.8	0.2	1.8	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.04.30

LAND BASED TEST

TITLE SEAWATER TEST 4

TRO Graph

Obj. **FILTER + ELECTROLYSIS, SW 4**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.04.22	13:50	2010.04.22	11:04
END, BALLASTING	-	2010.04.22	15:08	2010.04.22	12:19
START, DEBALLASTING	-	2010.04.27	13:25	2010.04.27	11:20
END, DEBALLASTING	-	2010.04.27	14:27	2010.04.27	12:16

Test duration		
75	min	Treatment, B
78	min	Control, B
56	min	Treatment, DB
62	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	192	200	207
DOSAGE	mg/L	6.68	8.67	10.24
FILTER BACKFLUSHING (COUNT)	n/hr		33	
Electrolyzer Voltage	V		48.5	
Electrolyzer Current	A		135.4	
Water Temperature	℃	12.3	12.55	12.8
Electrolysis Unit Power Consumption	kW		6.6	
Electrolysis Unit Energy Consumption	kWh		8.3	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.04.22		0	8.67		
Day 0, after operation	mg/L	2010.04.22	12:40	0	7.24	0	
Day 1	mg/L	2010.04.23		1	5.6	0.25685	
Day 2	mg/L	2010.04.24		2	5.13		
Day 3	mg/L	2010.04.25		3	4.69		
Day 4	mg/L	2010.04.26		4	4.39		
Day 5, before neutralization	mg/L	2010.04.27		5	4.28	0.52567	0.105
Day 5, after neutralization	mg/L	2010.04.27			0.07		
Decay Constant	1/day	Temp.	13.59		0.11		

Chlorine demand, 20 min: 1.89 mg/L

9.13 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	307,000.0	236,000.0	2,216.7	0.0		0.0	100.0000	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	1,363.3	1,481.4	325.3	0.3		0.6	99.9756	99.9593
Heterotrophs	cfu/ml	8,590.0	15,533.0	2,222.3	0.0		69.0	100.0000	99.1967
Coliform	cfu/ml	TNTC*	7.0	264.0	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	22.0	TNTC	0.0	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	577.0	408.3	49.0	0.0		2.0	100.0000	99.6534
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	12.4	12.4	14.1	12.4	13.8	14.5	
pH	-	7.9	8.0	7.6	8.0	7.8	7.8	
ORP	mV	557.0	627.0	610.7	956.7	903.0	724.7	
Salinity (> 33 PSU)	PSU	35.2	35.4	35.2	35.3	35.3	35.3	
DO	mg/L	8.7	8.9	7.9	8.3	8.2	8.2	
Turbidity(NTU)	NTU	5.0	4.5	1.8	4.0	2.2	3.5	
TSS (> 1 mg/L)	mg/L	17.6	19.3	13.2	19.6		17.6	
DOC (> 1 mg/L)	mg/L	2.3	2.3	1.4	2.4	2.6	2.6	
POC (> 1 mg/L)	mg/L	1.5	1.4	0.3	1.6	0.3	1.4	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.05.07

LAND BASED TEST

TITLE SEAWATER TEST 5

Obj. **FILTER + ELECTROLYSIS, SW 5**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.04.29	13:43	2010.04.29	11:17
END, BALLASTING	-	2010.04.29	15:03	2010.04.29	12:32
START, DEBALLASTING	-	2010.05.04	15:08	2010.05.04	14:07
END, DEBALLASTING	-	2010.05.04	16:09	2010.05.04	14:57

Test duration		
75	min	Treatment, B
80	min	Control, B
50	min	Treatment, DB
61	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	186	201	216
DOSAGE	mg/L	7.19	8.37	9.1
FILTER BACKFLUSHING (COUNT)	n/hr		60	
Electrolyzer Voltage	V		48.58	
Electrolyzer Current	A		134.85	
Water Temperature	°C	12.1	12.4	12.7
Electrolysis Unit Power Consumption	kW		6.6	
Electrolysis Unit Energy Consumption	kWh		8.3	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.04.29		0	8.37		
Day 0, after operation	mg/L	2010.04.29	13:00	0	7.54	0	
Day 1	mg/L	2010.04.30		1	6.38	0.16705	
Day 2	mg/L	2010.05.01		2			
Day 3	mg/L	2010.05.02		3			
Day 4	mg/L	2010.05.03		4			
Day 5, before neutralization	mg/L	2010.05.04		5	4	0.63393	0.127
Day 5, after neutralization	mg/L	2010.05.04			0.03		
Decay Constant	1/day	Temp.	15.59		0.13		

Chlorine demand, 20 min: 2.26 mg/L

9.8 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	399,000.0	195,000.0	4,233.3	0.0		0.0	100.0000	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	2,339.7	1,706.4	260.3	0.3		0.7	99.9858	99.9715
Heterotrophs	cfu/ml	14,090.0	11,199.7	2,066.7	0.0		36.7	100.0000	99.7398
Coliform	cfu/ml	TNTC*	TNTC	6.7	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	TNTC	TNTC	7.0	0.0		0.0		
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	TNTC	TNTC	141.7	0.0		0.0		
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	°C	11.9	12.3	16.6	12.4	16.8	17.5	
pH	-	7.8	7.8	7.6	7.7	7.8	7.7	
ORP	mV	558.0	745.0	599.7	969.0	921.0	628.7	
Salinity (> 33 PSU)	PSU	35.6	35.6	35.5	35.5	35.5	35.5	
DO	mg/L	8.7	8.9	7.6	8.3	8.2	7.8	
Turbidity(NTU)	NTU	8.3	9.2	2.7	8.4	2.8	7.2	
TSS (> 1 mg/L)	mg/L	22.1	23.9	20.6	22.6		13.3	
DOC (> 1 mg/L)	mg/L	2.3	2.2	1.2	2.4	2.4	2.4	
POC (> 1 mg/L)	mg/L	1.8	1.8	0.2	1.7	0.2	1.5	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.05.14

LAND BASED TEST

TITLE SEAWATER TEST 6

Obj. **FILTER + ELECTROLYSIS, SW 6**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.07.08	13:30	2010.07.08	10:46
END, BALLASTING	-	2010.07.08	14:50	2010.07.08	12:10
START, DEBALLASTING	-	2010.07.13	13:10	2010.07.13	11:23
END, DEBALLASTING	-	2010.07.13	14:13	2010.07.13	12:22

Test duration		
84	min	Treatment, B
80	min	Control, B
59	min	Treatment, DB
63	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	202	213
DOSAGE	mg/L	8	8.95	9.9
FILTER BACKFLUSHING (COUNT)	n/hr		30	
Electrolyzer Voltage	V		49.1	
Electrolyzer Current	A		142.74	
Water Temperature	℃	20.7	21.25	21.8
Electrolysis Unit Power Consumption	kW		7.0090	
Electrolysis Unit Energy Consumption	kWh		9.8	

Neutralizing agent, equivalent: 2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.07.08		0	8.95		
Day 0, after operation	mg/L	2010.07.08	12:40	0	7.88	0	
Day 1	mg/L	2010.07.09		1	4.97		
Day 2	mg/L	2010.07.10		2			
Day 3	mg/L	2010.07.11		3			
Day 4	mg/L	2010.07.12		4	2.3		
Day 5, before neutralization	mg/L	2010.07.13		5	2.1	1.32239	0.264
Day 5, after neutralization	mg/L	2010.07.13			0.1		
Decay Constant	1/day	Temp.	21.68		0.26		

Chlorine demand, 20 min		
2.78	mg/L	KTR
10.66	Injection Co	7.91
		4
		2.1

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	864,166.0	141,999.7	2,860.7	2.3		0.0	99.9997	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	1,522.0	1,664.7	247.8	1.0		0.3	99.9343	99.9781
Heterotrophs	cfu/ml	10,590.0	15,355.3	5,977.7	0.7		524.3	99.9937	95.0488
Coliform	cfu/ml	TNTC*	TNTC	TNTC	0.0		TNTC		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	720.0	TNTC	18.0	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	427.0	370.0	89.0	0.0		1.0	100.0000	99.7658
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	20.1	20.8	22.1	20.7	22.0	22.3	
pH	-	7.7	7.8	7.1	7.8	7.6	7.6	
ORP	mV	319.0	365.0	372.3	775.7	701.0	489.7	
Salinity (> 33 PSU)	PSU	34.3	34.3	34.4	34.3	34.4	34.4	
DO	mg/L	7.5	8.2	6.6	7.4	7.3	7.5	
Turbidity(NTU)	NTU	4.3	4.2	3.1	4.1	1.4	3.8	
TSS (> 1 mg/L)	mg/L	20.8	24.5	9.2	19.4		11.4	
DOC (> 1 mg/L)	mg/L	2.6	2.4	1.8	3.2	3.6	3.7	
POC (> 1 mg/L)	mg/L	1.3	1.6	0.4	2.1	0.4	1.7	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.07.23

LAND BASED TEST

TITLE BRACKISH WATER TEST 1

Obj. **FILTER + ELECTROLYSIS, BW 1**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.05.27	13:17	2010.05.27	11:07
END, BALLASTING	-	2010.05.27	14:36	2010.05.27	12:22
START, DEBALLASTING	-	2010.06.01	13:00	2010.06.01	11:03
END, DEBALLASTING	-	2010.06.01	14:03	2010.06.01	11:59

Test duration		
75	min	Treatment, B
79	min	Control, B
56	min	Treatment, DB
63	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	195	203	210
DOSAGE	mg/L	8	8.75	9.5
FILTER BACKFLUSHING (COUNT)	n/hr		30	
Electrolyzer Voltage	V		52.7	
Electrolyzer Current	A		135.32	
Water Temperature	℃	14.1	14.45	14.8
Electrolysis Unit Power Consumption	kW		7.1	
Electrolysis Unit Energy Consumption	kWh		8.9	

Neutralizing agent, equivalent: 3.2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.05.27		0	8.75		
Day 0, after operation	mg/L	2010.05.27	12:50	0	6.8	0	
Day 1	mg/L	2010.05.28		1	2.8		
Day 2	mg/L	2010.05.29		2			
Day 3	mg/L	2010.05.30		3	0.85		
Day 4	mg/L	2010.05.31		4	0.6		
Day 5, before neutralization	mg/L	2010.06.01		5	0.45	2.71543	0.543
Day 5, after neutralization	mg/L	2010.06.01			0.06		
Decay Constant	1/day	Temp.	15.60		0.54		

Chlorine demand, 20 min: 1.94 mg/L

8.74 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	310,000.0	85,833.3	3,833.3	5.7		0.0	99.9982	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	2,133.7	2,065.1	718.3	0.9		0.3	99.9583	99.9844
Heterotrophs	cfu/ml	24,000.0	24,633.0	22,477.7	0.0		1,806.7	100.0000	92.4722
Coliform	cfu/ml	TNTC*	TNTC	TNTC	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	215.0	TNTC	1.0	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	308.0	339.0	41.0	0.0		13.0	100.0000	95.7792
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	14.0	14.3	15.9	14.4	16.1	16.4	
pH	-	7.9	8.0	7.1	8.2	7.4	7.6	
ORP	mV	529.0	776.3	549.0	956.0	551.0	701.3	
Salinity (> 33 PSU)	PSU	20.4	20.4	20.4	20.4	20.3	20.4	
DO	mg/L	9.0	9.8	8.0	8.8	8.6	8.7	
Turbidity(NTU)	NTU	29.4	29.1	7.4	27.4	5.4	19.1	
TSS (> 1 mg/L)	mg/L	89.5	81.1	20.6	78.8		52.3	
DOC (> 1 mg/L)	mg/L	8.9	9.6	7.7	10.2	10.0	10.0	
POC (> 1 mg/L)	mg/L	17.4	19.3	3.6	20.5	1.1	13.7	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.06.11

LAND BASED TEST

TITLE BRACKISH WATER TEST 2

Obj. **FILTER + ELECTROLYSIS, BW 2, By-products Analysis**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.06.03	13:18	2010.06.03	10:48
END, BALLASTING	-	2010.06.03	14:30	2010.06.03	12:07
START, DEBALLASTING	-	2010.06.08	13:34	2010.06.08	11:36
END, DEBALLASTING	-	2010.06.08	14:30	2010.06.08	12:31

Test duration		
79	min	Treatment, B
72	min	Control, B
55	min	Treatment, DB
56	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	202	213
DOSAGE	mg/L	7.5	8.5	9.5
FILTER BACKFLUSHING (COUNT)	n/hr		11	
Electrolyzer Voltage	V		51.58	
Electrolyzer Current	A		135.05	
Water Temperature	℃	17.2	17.6	18
Electrolysis Unit Power Consumption	kW		7	
Electrolysis Unit Energy Consumption	kWh		9.2	

Neutralizing agent, equivalent: 3.2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.06.03		0	8.5		
Day 0, after operation	mg/L	2010.06.03	12:30	0	6.71	0	
Day 1	mg/L	2010.06.04		1	2.5		
Day 2	mg/L	2010.06.05		2			
Day 3	mg/L	2010.06.06		3			
Day 4	mg/L	2010.06.07		4	0.46		
Day 5, before neutralization	mg/L	2010.06.08		5	0.27	3.21293	0.643
Day 5, after neutralization	mg/L	2010.06.08			0.04		
Decay Constant	1/day	Temp.	19.85		0.64		

Chlorine demand, 20 min: 1.98 mg/L

8.69 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	163,000.0	10,294.3	4,150.0	5.7		0.3	99.9965	99.9998
> 10 ㎛ and < 50 ㎛	organisms/ml	1,374.0	1,894.0	290.1	0.7		0.7	99.9515	99.9515
Heterotrophs	cfu/ml	22,864.0	22,622.3	9,599.7	1.0		1,861.0	99.9956	91.8606
Coliform	cfu/ml	TNTC*	52.0	TNTC	0.0		57.3		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	30.0	TNTC	1.0	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	495.0	530.0	203.7	0.0		17.3	100.0000	96.4983
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	17.2	17.6	20.6	18.0	20.6	21.0	
pH	-	8.1	8.1	6.9	8.2	7.6	7.7	
ORP	mV	527.0	685.7	463.3	949.0	530.0	500.0	
Salinity (> 33 PSU)	PSU	20.4	20.5	20.5	20.4	20.4	20.5	
DO	mg/L	8.5	9.2	7.3	8.4	8.0	8.0	
Turbidity(NTU)	NTU	23.8	25.3	6.9	23.8	3.3	12.8	
TSS (> 1 mg/L)	mg/L	82.7	74.7	17.7	75.5		39.3	
DOC (> 1 mg/L)	mg/L	7.7	7.6	5.8	7.6	7.8	7.9	
POC (> 1 mg/L)	mg/L	21.1	17.9	3.4	20.4	0.9	10.2	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.06.18

LAND BASED TEST

TITLE BRACKISH WATER TEST 3

Obj. **FILTER + ELECTROLYSIS, BW 3**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.06.10	13:17	2010.06.10	10:45
END, BALLASTING	-	2010.06.10	14:33	2010.06.10	12:05
START, DEBALLASTING	-	2010.06.15	13:31	2010.06.15	11:20
END, DEBALLASTING	-	2010.06.15	14:36	2010.06.15	12:21

Test duration		
80	min	Treatment, B
76	min	Control, B
61	min	Treatment, DB
65	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	202	213
DOSAGE	mg/L	9.5	10	10.5
FILTER BACKFLUSHING (COUNT)	n/hr		10	
Electrolyzer Voltage	V		53.08	
Electrolyzer Current	A		159.4	
Water Temperature	°C	20	20.4	20.8
Electrolysis Unit Power Consumption	kW		8.5	
Electrolysis Unit Energy Consumption	kWh		11.3	

Neutralizing agent, equivalent: 3.2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.06.10		0	10		
Day 0, after operation	mg/L	2010.06.10	12:30	0	8.42	0	
Day 1	mg/L	2010.06.11		1	3.55		
Day 2	mg/L	2010.06.12		2			
Day 3	mg/L	2010.06.13		3			
Day 4	mg/L	2010.06.14		4			
Day 5, before neutralization	mg/L	2010.06.15		5	0.97	2.16107	0.432
Day 5, after neutralization	mg/L	2010.06.15			0.08		
Decay Constant	1/day	Temp.	21.74		0.43		

Chlorine demand, 20 min: 2.45 mg/L

10.87 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	755,000.0	121,333.3	49,666.7	16.0		0.0	99.9979	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	2,131.7	2,026.8	456.3	0.0		0.0	100.0000	100.0000
Heterotrophs	cfu/ml	22,545.0	19,255.7	TNTC	0.0		1,343.3	100.0000	94.0415
Coliform	cfu/ml	TNTC*	TNTC	TNTC	0.0		93.7		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	10.0	TNTC	0.3	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	697.0	490.3	50.0	0.0		16.7	100.0000	97.6088
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	°C	19.8	20.4	22.6	20.5	22.0	22.7	
pH	-	8.1	8.2	6.9	7.9	7.6	7.6	
ORP	mV	505.0	680.3	429.0	951.0	740.0	566.0	
Salinity (> 33 PSU)	PSU	20.7	20.7	20.7	20.6	20.8	20.8	
DO	mg/L	9.2	8.7	7.0	7.8	7.7	7.9	
Turbidity(NTU)	NTU	23.5	26.2	9.8	21.9	2.5	10.7	
TSS (> 1 mg/L)	mg/L	78.9	82.0	23.1	76.4		39.8	
DOC (> 1 mg/L)	mg/L	6.7	7.0	5.2	7.1	7.5	7.4	
POC (> 1 mg/L)	mg/L	19.4	18.7	3.7	19.3	0.8	8.5	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.06.25

LAND BASED TEST

TITLE BRACKISH WATER TEST 4

Obj. **FILTER + ELECTROLYSIS, BW 4**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.06.17	13:10	2010.06.17	10:50
END, BALLASTING	-	2010.06.17	14:25	2010.06.17	12:07
START, DEBALLASTING	-	2010.06.22	13:47	2010.06.22	11:53
END, DEBALLASTING	-	2010.06.22	14:49	2010.06.22	12:46

Test duration		
77	min	Treatment, B
75	min	Control, B
53	min	Treatment, DB
62	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	202	213
DOSAGE	mg/L	9	9.6	10.2
FILTER BACKFLUSHING (COUNT)	n/hr		5	
Electrolyzer Voltage	V		52.03	
Electrolyzer Current	A		160.32	
Water Temperature	°C	21.8	22.5	23.2
Electrolysis Unit Power Consumption	kW		8.3	
Electrolysis Unit Energy Consumption	kWh		10.7	

Neutralizing agent, equivalent: 3.2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.06.17		0	9.6		
Day 0, after operation	mg/L	2010.06.17	12:30	0	8.54	0	
Day 1	mg/L	2010.06.18		1	3.12		
Day 2	mg/L	2010.06.19		2			
Day 3	mg/L	2010.06.20		3			
Day 4	mg/L	2010.06.21		4	0.9		
Day 5, before neutralization	mg/L	2010.06.22		5	0.65	2.57554	0.515
Day 5, after neutralization	mg/L	2010.06.22			0.07		
Decay Constant	1/day	Temp.	23.51		0.52		

Chlorine demand, 20 min: 2.45 mg/L

10.99 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	415,000.0	190,666.7	2,750.0	22.7		0.0	99.9945	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	2,099.0	1,782.3	519.3	0.7		0.0	99.9682	100.0000
Heterotrophs	cfu/ml	44,909.0	30,055.3	33,833.0	0.0		1,410.3	100.0000	96.8596
Coliform	cfu/ml	TNTC*	TNTC	0.0	0.0		0.0		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	277.0	TNTC	4.3	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	898.0	372.7	87.7	0.0		9.7	100.0000	98.9235
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	°C	21.9	22.5	24.3	22.3	23.7	24.5	
pH	-	8.2	8.2	7.4	8.3	8.1	8.2	
ORP	mV	392.0	575.3	210.0	931.0	457.0	429.7	
Salinity (> 33 PSU)	PSU	20.7	20.5	20.5	20.6	20.7	20.7	
DO	mg/L	8.4	8.9	7.0	8.0	7.7	7.9	
Turbidity(NTU)	NTU	21.6	22.9	7.4	20.6	3.0	9.4	
TSS (> 1 mg/L)	mg/L	81.3	82.0	18.9	73.2		32.2	
DOC (> 1 mg/L)	mg/L	5.5	5.4	7.8	6.8	7.1	7.0	
POC (> 1 mg/L)	mg/L	17.0	19.1	3.1	18.3	0.6	6.9	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.07.02

LAND BASED TEST

TITLE BRACKISH WATER TEST 5

Obj. **FILTER + ELECTROLYSIS, BW 5**

OPERATION LOG	HHI	CONTROL Date	CONTROL Time	TREATED Date	TREATED Time
START, BALLASTING	-	2010.06.24	13:13	2010.06.24	10:28
END, BALLASTING	-	2010.06.24	14:32	2010.06.24	11:46
START, DEBALLASTING	-	2010.06.29	14:08	2010.06.29	11:27
END, DEBALLASTING	-	2010.06.29	15:11	2010.06.29	12:27

Test duration		
78	min	Treatment, B
79	min	Control, B
60	min	Treatment, DB
63	min	Control, DB

OPERATING CONDITION	HHI	Min.	Average	Max.
FLOW	m³/hr	190	202	213
DOSAGE	mg/L	9.5	10	10.5
FILTER BACKFLUSHING (COUNT)	n/hr		17	
Electrolyzer Voltage	V		52.55	
Electrolyzer Current	A		161.05	
Water Temperature	℃	20.2	20.65	21.1
Electrolysis Unit Power Consumption	kW		8.5	
Electrolysis Unit Energy Consumption	kWh		11.1	

Neutralizing agent, equivalent: 3.2

TRO degradation	HHI, KTR	Date	Time	Time (day)	TRO	ln(C0/C)	k
Day 0, operation	mg/L	2010.06.24		0	10		
Day 0, after operation	mg/L	2010.06.24	12:10	0	8.2	0	
Day 1	mg/L	2010.06.25		1	2.9		
Day 2	mg/L	2010.06.26		2			
Day 3	mg/L	2010.06.27		3			
Day 4	mg/L	2010.06.28		4	0.78		
Day 5, before neutralization	mg/L	2010.06.29		5	0.7	2.46081	0.492
Day 5, after neutralization	mg/L	2010.06.29			0.08		
Decay Constant	1/day	Temp.	21.68		0.49		

Chlorine demand, 20 min: 2.436 mg/L

10.636 Injection Conc. (mg/L)

PERFORMANCE Organisms	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMOVAL D0,(%)	REMOVAL D5,(%)
> 50 ㎛	organisms/m³	508,000.0	180,666.3	20,333.0	48.7		0.0	99.9904	100.0000
> 10 ㎛ and < 50 ㎛	organisms/ml	1,923.3	1,587.1	252.6	0.3		1.1	99.9827	99.9422
Heterotrophs	cfu/ml	44,682.0	20,355.7	TNTC	0.0		2,437.7	100.0000	94.5444
Coliform	cfu/ml	TNTC*	TNTC	39.0	0.0		72.3		
E. Coli (< 250 cfu/100 ml)	cfu/100 ml	900.0	TNTC	17.3	0.0		0.0	100.0000	100.0000
Enterococci (< 100 cfu/100 ml)	cfu/100 ml	898.0	1,124.7	228.3	0.0		24.3	100.0000	97.2903
Vibrio Chloerlae (<1 cfu/100 ml)	cfu/100 ml	0.0	0.0	0.0	0.0		0.0		

Water quality	KOMERI	TEST WATER	CONTROL D0	CONTROL D5	TREATED D0	TREATED D5	TREATED D5 (N)	REMARK
Water temperature	℃	20.2	20.9	22.3	21.1	21.3	22.6	
pH	-	8.9	9.0	6.7	9.1	7.4	7.4	
ORP	mV	469.0	511.3	164.3	901.3	306.0	292.3	
Salinity (> 33 PSU)	PSU	20.5	20.5	20.0	20.4	20.0	19.9	
DO	mg/L	8.9	9.2	8.2	8.2	7.8	8.3	
Turbidity(NTU)	NTU	21.3	21.7	8.1	19.4	2.7	8.5	
TSS (> 1 mg/L)	mg/L	71.7	67.6	22.6	72.8		28.2	
DOC (> 1 mg/L)	mg/L	7.3	7.5	7.2	7.8	8.0	7.8	
POC (> 1 mg/L)	mg/L	17.4	16.1	3.8	18.0	0.8	6.5	

Checked by KOMERI:	Jun-Hyuk Yang		Date (YYYY.MM.DD) 2010.07.09