TECHNICAL REPORT

INTERNATIONAL WATER TREATMENT MARITIME (IWTM) AS

EVALUATION OF ELYSATOR WATER TREATMENT UNIT

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DET NORSKE VERITAS

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Summary:

Det Norske Veritas (DNV), Department for Materials and Inspection Technology in Bergen, has evaluated the effect of a water treatment unit called Elysator. The effect is evaluated as the ability to reduce the aggressivity of water with regard to corrosion. The evaluation is based on results from analyses of water flowing in closed circuits (cooling and heating systems, including steam plants) where this type of unit is installed.

The results of the analyses show that the water treatment unit reduces the chloride content and the conductivity of the water and increases the pH. This reduces the corrosion susceptibility of metal alloys exposed to the water. An indication of such effect is given by the recorded reduction of iron and copper content as a function of water treatment time.

The results of the water analyses further show that the carbon content is reduced as result of the water treatment. Such reduction limits any bacterial growth and hence the risk of microbiologically influenced corrosion (MIC).

It is concluded that the aggressivity of the water with regard to corrosion is significantly reduced as result of the water treatment.

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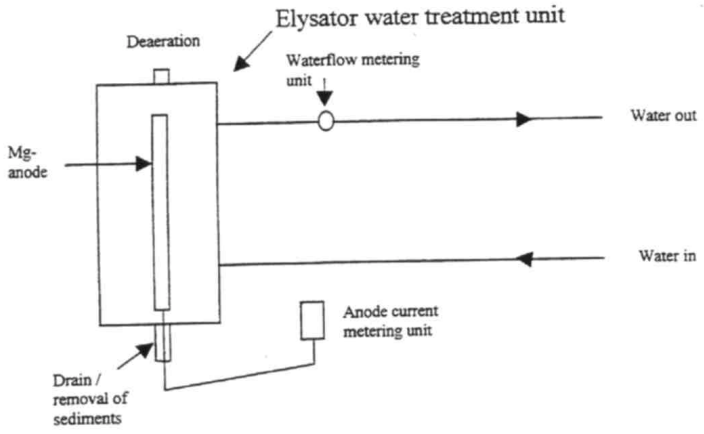
1 INTRODUCTION

DNV, Department for Materials and Inspection Technology in Bergen, has received data for a water treatment unit called Elysator. DNV has further received results from analyses of water that has been treated by means of the unit. Based on the received information, DNV has evaluated the effect of the unit.

2 TECHNICAL INFORMATION

Elysator is a unit for treatment of water in closed heat transfer systems for heating, cooling and steam purposes. The unit is installed in a by-pass, so that approximately 1 to 3 % by volume of the water flows through it. The main functions of the water treatment unit are to regulate the pH, reduce the conductivity and to remove the oxygen from the water, further to remove any sediments from the systems in which it is installed. A sketch of the unit is shown in fig. 1.



3 RESULTS OF WATER ANALYSES

The following heat transfer systems where the water treatment unit are installed, are evaluated:

- 1 cooling system on board Havfrost
- 1 cooling system on board MS Nordic Empress
- 1heating system at the Universitet of Oslo
- 1 heating system at Det Norske Veritas in Oslo
- 2 cooling systems at Det Norske Veritas in Oslo
- 1 steam plant on board MV Ballangen
- 1 steam plant on board MV Tanabata

Water analyses have been performed at the following laboratories:

- NIVA (Norsk Institutt for vannforskning)
- Thornton laboratories
- SGS
- Kjelforeningen, Norsk Energi
- IWTM
- Unitor

Some of the analyses are further performed on board MV Ballangen.

The results of the water analyses from the different systems are shown in table 3.1 to 3.7.

3.1 Results of water analyses from low temperature cooling system on board Havfrost,

Parameter	Name of laboratory and sampling date					
	NIVA 20.02.95	**Thornton 17.04.95**	**SGS 01.05.95**	**NIVA 12.05.95**	**SGS 03.09.95**	**SGS 22.03.96**
pH	8.91	8.9	9.2	9.12	9.4	9.0
Conductivity (µS/cm)	5950	5950	5500	5360	3600	746
Tot. organic carbon (mg C/l)	161	0	13	15.9	7.6	2.6
Chloride (mg Cl/l)	31	1000	39	≈ 30	5	3.4
Iron (mg Fe/l)	0.5	0.37	0.19	0.82	0.049	<1
Copper (mg Cu/l)	0.16	0.15	0.10	0.17	0.059	<1
Hardness (mmol/l Ca/Mg)	Not analysed	86	1200	Not analysed	1.59	≈ 0.54 (50 mg/l $CaCO_3$)

The first set of results (20.02.95) refers to sampling which was carried out before installation of the water treatment unit

3.2 Results of water analyses from high temperature cooling system on board Havfrost,

Parameter	Name of laboratory and sampling date				
	NIVA 20.02.95	SGS 01.05.95	NIVA 12.05.95	SGS 03.09.95	SGS 22.03.96
pH	8.9	9.2	9.04	9.5	8.7
Conductivity (µS/cm)	5020	2850	1690	59	1.07
Tot. organic carbon (mg C/l)	193	7.9	7.8	3.1	6.1
Chloride (mg Cl/l)	14	12	≈ 4-5	28	1.3
Iron (mg Fe/l)	0.23	0.016	0.013	0.048	<1
Copper (mg Cu/l)	0.07	0.065	0.016	0.010	<1
Hardness (mmol/l Ca/Mg)	Not analysed	540	Not analysed	0.24	≈ 0.28 (25 mg/l $CaCO_3$)

The first set of results (20.02.95) refers to sampling which was carried out before installation of the water treatment unit

In addition to the results listed in table 3.1 and 3.2, results from bacteria counting have been received. However, the type of bacteria recorded and the counting methods which have been performed vary between the different laboratories. This render an evaluation of the bacteria activity as function of water treatment time. The results are therefore omitted.

3.3 Results of water analyses from cooling system on board MS Nordic Empress

Parameter	Name of laboratory and sampling date						
	Kjel-foreningen - Norsk Energi 20.08.97	Kjel-foreningen - Norsk Energi 27.10.97	Kjel-foreningen - Norsk Energi 24.11.97	Kjel-foreningen – Norsk Energi 22.12.97	Kjel-foreningen – Norsk Energi 14.01.98	Kjel-foreningen – Norsk Energi 17.02.98	Kjel-foreningen – Norsk Energi 02.04.98
pH	9.6	9.2	9.4	9.4	8.9	8.3	9.4
Conductivity (µS/cm)	5420	2210	1930	1690	1396	396	372
Chloride (mg Cl/kg)	115	78	70	73	68.2	35.5	35.4
Iron (mg Fe/l)	0.83	0.46	0.13	0.02	0.02	0.14	0.12
Copper (mg Cu/l)	0.26	0.18	0.04	0.03	0.03	0.06	0.05
Hardness (dH)*	0.39		1.8	5.2	1.84	1.65	1.09
Sulfate ($mgSO_4$/kg)	8.5	9.8	7.8	<1.0	<1.0	<1.0	<1.0

* 1 dH = 7.2 mg Ca/l = 0.18 mmol Ca/l

The first set of results (20.08.97) refers to sampling which was carried out before installation of the water treatment unit

3.4 Results of water analyses from the heating system at the University of Oslo

Parameter	Name of laboratory and sampling date		
	Kjelforeningen – Norsk Energi 29.07.93	Kjelforeningen - Norsk Energi 02.12.93	Kjelforeningen – Norsk Energi 27.01.94
pH	9.1	7.5	8.9
Conductivity (µS/cm)	Not analysed	42.1	43.2
Iron (mg Fe/l)	0.42	0.37	0.07
Copper (mg Cu/l)	0.2	< 0.2	< 0.2

The first set of results (29.07.93) refers to sampling which was carried out before installation of the water treatment unit

3.5 Results of water analyses from the heating system at Det Norske Veritas

Parameter	Name of laboratory and sampling date				
	Kjelforeningen - Norsk Energi 02.11.92	Kjelforeningen – Norsk Energi 19.01.93	Kjelforeningen – Norsk Energi 15.04.93	Kjelforeningen – Norsk Energi 19.08.93	Kjelforeningen – Norsk Energi 15.02.94
pH	7.6	9.0	8.8	9.3	9.2
Conductivity (µS/cm)	88.0	93.5	88.0	79.2	86.9
Iron (mg Fe/l)	0.64	0.35	0.18	0.30	0.37
Copper (mg Cu/l)	0.10	0.10	0.05	0.04	0.02

The first set of results (02.11.92) refers to sampling which was carried out before installation of the water treatment unit

3.6 Results of water analyses from cooling system, "west" at Det Norske Veritas

Parameter	Name of laboratory and sampling date				
	Kjelforeningen - Norsk Energi 27.10.92	Kjelforeningen – Norsk Energi 19.01.93	Kjelforeningen – Norsk Energi 15.04.93	Kjelforeningen – Norsk Energi 19.08.93	Kjelforeningen – Norsk Energi 15.02.94
pH	7.7	9.1	8.5	9.3	9.2
Conductivity (µS/cm)	60.5	63.8	55.1	59.4	59.4
Iron (mg Fe/l)	8.2	2.2	1.4	0.32	0.14
Copper (mg Cu/l)	0.03	0.13	0.03	0.04	0.02

The first set of results (27.10.92) refers to sampling which was carried out before installation of the water treatment unit

3.7 Results of water analyses from cooling system, "east" at Det Norske Veritas

Parameter	Name of laboratory and sampling date				
	Kjelforeningen - Norsk Energi 27.10.92	Kjelforeningen – Norsk Energi 19.01.93	Kjelforeningen – Norsk Energi 15.04.93	Kjelforeningen – Norsk Energi 19.08.93	Kjelforeningen – Norsk Energi 15.02.94
pH	8.6	9.1	9.6	9.5	9.6
Conductivity (µS/cm)	242	71.5	57.2	61.6	66.0
Iron (mg Fe/l)	16	0.42	1.7	6.9	0.16
Copper (mg Cu/l)	0.03	0.02	0.05	0.09	0.02

The first set of results (27.10.92) refers to sampling which was carried out before installation of the water treatment unit

3.8 Results of water analyses from steam plant on board MV Ballangen

Parameter	Name of laboratory and sampling date			
	Kjelforeningen – Norsk Energi 11.11.94	Kjelforeningen – Norsk Energi 03.02.95	IWTM 28.10.97	MV Ballangen 25.01.98
pH	9.6	9.5	10.9	11
Conductivity (µS/cm)	637	258	400	200
Chloride (mg Cl/kg)	140	51.1	34.5	20
Iron (mg Fe/l)	1.0	1.0	0.01	Not measured
Copper (mg Cu/l)	0.7	0.04	0.14	Not measured
Hardness (dH)*	4.9	2.28	3.65	Not measured
Sulfate (mg SO_4/l)	Not measured	Not measured	31	Not measured

* 1 dH = 7.2 mg Ca/l = 0.18 mmol Ca/l

The first set of results (11.11.94) refers to sampling which was carried out before installation of the water treatment unit

3.9 Results of water analyses from steam plant on board MV Tanabata

Parameter	Name of laboratory and sampling date			
	IWTM 08.07.96	IWTM 02.11.96	IWTM 30.11.97	Unitor 16.03.98
pH	8.3	10.2	10.4	9.5
Conductivity (µS/cm)	110	210	310	105
Chloride (mg Cl/kg)	16.5	31.5	0	<0.1
Iron (mg Fe/l)	0.02	0.03	0.02	<0.1
Copper (mg Cu/l)	0.1	0.1	0.07	<0.1
Hardness (dH)*	1.12	2.52	3.1	1.34
Sulfate (mg SO_4/l)	Not measured	15	64	Not measured

* 1 dH = 7.2 mg Ca/l = 0.18 mmol Ca/l

The first set of results (08.07.96) refers to sampling which was carried out before installation of the water treatment unit

4 EVALUATIONS/CONCLUSION

The results of the water analyses show that the pH is regulated to a stable level around 9. They further show a reduction of chloride content as function of water treatment time. These parameters affect the water quality so that the aggressivity with regard to corrosion is reduced.

Further the carbon content in the water is reduced as function of water treatment time. Any bacteria in the water are dependent of carbon to live, and a carbon reduction therefore limits the bacteria activity and hence the microbiological influenced corrosion (MIC) which often occurs in closed circuit systems of water.

Generally a significant reduction of the conductivity as function of water treatment time is recorded. Similar trends are not found in the results of the water sample analyses from the heating system and the cooling system "west" at DNV, from the steam plant on board MV Tanabata or from the heating system at the University of Oslo. However the conductivity values in these waters were relatively low before the water treatment units were installed. The conductivity of the water is a measure for the flow rate of charged electrons, and the higher the value, the better conductivity. The conductivity affects the corrosion susceptibility of most metal alloys, and generally the corrosion rates are higher in waters with high conductivity than in waters with low conductivity.

The results of the water analyses show a significant reduction of the iron and copper content as function of water treatment time. This indicates that iron and copper ions in the water are removed from the water. It also indicates that corrosion rates of copper and iron alloys in the heat transfer systems are lowered as result of the water treatment.

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