Great Ships Initiative

April 28, 2010

A Great Lakes Relevancy Preamble
to the
GSI Report on Land-Based Testing Outcomes
for the Siemens SiCURE™ Ballast Water Management System

Allegra Cangelosi, PI

Siemens SiCURE ™ Ballast Water Management System performance evaluation tests were undertaken at the Great Ships Initiative (GSI) land-based test site in Superior, WI in September and October 2009. The independent GSI tests were arranged under agreement with the Siemens Water Technologies for submission to the German Administration which is considering type approving the system. The GSI report, Report of the Land-Based Freshwater Testing of the Siemens SiCURE™ Ballast Water Management System, on the performance of the SiCURE™ system in the fresh water context was therefore prepared specifically for use by the German Administration in making a determination as to whether the system performed in keeping with the International Maritime Organization (IMO) standards.

The GSI land-based tests showed the SiCURE™ system performance to be in keeping with IMO standards for biological performance and U.S. EPA discharge limits for residual chlorine. However, Great Lakes regulators, advocates and maritime industry representatives may wish to know how relevant the test outcomes are to potential **biological performance** in the Great Lakes. In particular,

- What was the system's effectiveness relative to the taxonomic categories of organisms in the Great Lakes, which may differ in size and morphology from their counterparts in brackish and saltwater systems?
- How did biological performance in these tests relate to potential performance relative to New York, Wisconsin or Minnesota ballast discharge standards?
- How did residual toxicity of discharge relate to State chemical discharge standards?

In addition, the Siemens Water Technologies designed the SiCURE™ system to meet the needs of ships that have long voyages and large ballasting flow rates. How applicable currently, or potentially, is this technology from an **operational performance** standpoint to ships that trade in the Great Lakes? For example,

- In what ways is the system currently compatible to Great Lakes fleets and trades? Special operational considerations include:
    - Salty and Canadian laker fleet: Voyage durations of days to weeks for ships in the salty fleet; and

  - U.S. laker fleet: Voyage duration of hours to days; no anticorrosion coatings on interiors of U.S. laker ballast tanks; entirely fresh water voyages; possibility of multiple ballast pumps and very high ballast flow rates.
- What adaptations might be necessary to enhance applicability?
- What is the general cost of this system?

This preamble addresses these Great Lakes-relevant questions. The factual information on treatment performance in terms of biological effectiveness and environmental soundness provided here is derived entirely from the GSI 2009 test outcomes. Opinions provided regarding readiness for adaptation to operational parameters of Great Lakes relevant fleets are those of the Siemens Water Technologies.

Great Lakes Relevant Biological Performance Considerations

All information derived from 2009 GSI land-based tests

1. *Great Lakes Special Consideration 1: "Below the Radar" Zooplankton*

The GSI land-based tests showed the Siemens SiCURE™ system to be capable of consistently meeting *International Maritime Organization (IMO) standards for biological performance*. The IMO standards related to plankton are rooted in size classes (e.g., 10 – 50 μm in minimum dimension, >50 μm in minimum dimension) rather than taxonomic categories (e.g., zooplankton, phytoplankton). These size delineations relate well to the taxonomic delineations in brackish and salt water assemblages. In the freshwater assemblages, however, the zooplankton can run smaller than in saltier environments, and some segment of the population will be below 50 μm in minimum dimension. Though this undersized segment of the overall zooplankton population can be small, it can also be most adept at withstanding filtration, depending upon filter pore size. Consequently, a treatment system which technically meets the IMO standard for the >50 μm size category in salt water may or may not deliver the same performance relative to zooplankton generally in the natural freshwater context.

During these tests, the generally undersized (<50 μm in minimum dimension) Lecanid rotifer was rarely detected in intake or control discharge samples in which live zooplankton numbered in the hundreds of thousands. However, in treated discharge where most if not all of the larger zooplankton were been removed by the 50 μm filtration component of the treatment system, from 1 to 5 live Lecanid rotifer individuals per cubic meter were detected. Table 1 contrasts performance relative to the size class regulated under the IMO standard (greater than 50 μm) versus zooplankton generally.

Table 1: Average Density (per m^3) of Live Zooplankton in Treatment Discharge during the Trials of the SiCURE™ System.

Test Trials:		Trial A	Trial B	Trial C	Trial D	Trial E
Total Vol. Treatment Discharge Analyzed, m^3:		**3.84**	**3.96**	**6.11**	**5.97**	**6.05**
Greater than 50 μm (min. dimension)						
Taxa Group	**Species**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**
Arachnida	Mite					0.17
Cladocerans	Bosmina				0.17	
	Daphnia				0.17	
Copepods	Copepod	0.79			0.17	
Diptera	Chironomid	2.08	4.03	2.79	2.36	0.66
Nematoda	Nematode				0.33	
Ostracoda	Ostracod				0.17	
Dreissena	Dreissenid (Zebra Mussel)		0.50			
Nauplii	Copepod Nauplii	1.56	2.52	1.32	0.34	0.66
Tardigrade	Tardigrade		0.49			
Rotifers	Bdelloid	0.52		0.33		
	Keratella				0.33	
Greater than 50 μm (min. dimension) Total:		**4.95**	**7.54**	**4.44**	**4.04**	**1.49**
Less than 50 μm (min. dimension)						
Taxa Group	**Species**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**	**Avg. Density (per m^3)**
Rotifers	Lecanidae	5.21	12.57	7.52	3.02	0.99
Less than 50 μm (min. dimension) Total:		**5.21**	**12.57**	**7.52**	**3.02**	**0.99**
Live Zooplankton Total:		**10.16**	**20.11**	**11.96**	**7.06**	**2.48**

2. Great Lakes Special Consideration 2: State Level Performance Standards Stricter than IMO

The States of Wisconsin and New York have issued ballast discharge standards that are 100 to 1000 times stricter than those contained in the IMO Convention. Based on the GSI tests, it is clear that the version of the treatment system evaluated at GSI, though it may meet the IMO standards, would not also meet the stricter state standards. Live zooplankton concentrations in the discharge from the GSI test facility samples would have had to have been far fewer than 1 per cubic meter, essentially a "non-detect", across all five trials, for it to be considered *possible* that the treatment could meet a standard even just 10 times higher than the IMO benchmark. In such a case, retesting with greater volumes of water or a greater number of replicates would be warranted to estimate to what extent the performance may exceed the IMO standard. But in these tests, densities of organisms in treated discharge in the regulated size class were always above 1 per cubic meter, and so no additional testing was needed. It is worth noting however, that the treatment was nonetheless highly effective, with densities encountered in the treated discharge 5 to 6 orders of magnitude lower than control (untreated) discharge.

3. *Great Lakes Special Consideration 3*: *Total Residual Chlorine and State Discharge Standards*

The undiluted discharge from this treatment process during the GSI land-based tests was consistently within U.S. EPA discharge limits for residual chlorine (0.1 mg/L, total residual chlorine or TRC). Upon reaching a receiving system with dissolved organic compounds in it, this TRC level can be expected to further decrease rapidly. However, there are special circumstances that limit prospective applicability of this version of the SiCURE™ system to ships in the Great Lakes trade. First, the discharge level of TRC achieved in the GSI tests followed a five day tank retention period (required for IMO-consistent tests); a shorter retention period likely would have resulted in discharge concentrations exceeding this level. As noted in table 2, U.S. lakers and Canadian laker voyages are hours to days, as opposed to five days or more. It is possible that the retention period requirement could be met in certain voyages of some salt water vessels that visit the Great Lakes, but not consistently.

In addition, under the Clean Water Act, some states like Wisconsin have established water quality standards which prohibit the discharge of chlorine above the established final acute value (FAV) of 0.04 mg/L $Cl_{2,}$ less than one half the national U.S. EPA criterion (table 3). In Wisconsin, an acute daily maximum of38 ug/l (0.038 mg/l) also is a water quality based limit, applicable at the end of the pipe (no mixing zone). Therefore, to comply with the Wisconsin state standard, the discharge would have to be actively neutralized or held even longer than 5 days for the chlorine to dissipate, prior to discharge.

In conclusion, as a practical matter, the SiCURE™ system would require a modification, specifically the addition of a neutralization step with another chemical such as sodium bisulfate, for it to have wide applicability to Great Lakes fleets. ***Fortunately, in recent weeks, Siemens has designed and implemented this modification such that neutralization occurs on an "as needed" basis, and is conducting land-based testing of the revised system in brackish water.*** They have not yet trialed the modification in freshwater.

Table 2. Physical Characteristics of Relevant Fleets/Trades of the Great Lakes-St. Lawrence Seaway System.

Type of vessel	Approx. number of vessels in global fleet	Average Length (m)	Average Beam (m)	Ballast capacity (m^3)	Typical[1] number of ballast pumps (#)	Typical ballast pump rate per pump (m^3/hour)	Typical[1] voyage duration (range)
Seaway-sized bulk carrier	1,028[2]	180	23	12,000	2	690	Days to weeks
Seaway-sized tanker	5,495[2]	135	23	5,000	2	300	Days to weeks
Seaway-sized general cargo carrier	12,048[2]	178	23	8,000	2	900	Days to weeks
United States Laker	41	230	24	20,000	2	2,400	Hours to days
United States 1000 ft Laker	11	303	32	50,000	4	2,900	Hours to days
Canadian Laker	80	190	21	15,000	2	1,000 – 2,000	Hours to days

[1] There are exceptions.
[2] Information from a 2001 vessel fleet analysis conducted by Lloyd's Maritime Information Services of London for the St. Lawrence Seaway Development Corporation. Analysis determined that 41,909 vessels, representing 69.7 percent of the world's fleet, are small enough to enter the St. Lawrence Seaway.

Table 3. State Residual Chlorine Discharge Standards.

State	Chlorine Discharge Standard (mg/L)
Indiana	0.02 (daily max.)
Illinois	0.05
Michigan	0.038
Minnesota	0.038
New York	0.005*
Ohio	0.038
Wisconsin	0.038

*Allowances incorporating dilution criteria when permitting can result in a range of 0.05-2.0 mg/L depending on the water classification for the discharge location.

April 28, 2010

Great Lakes Relevant Operational Performance Considerations

All information supplied by the Siemens Water Technologies

1. In what ways is the system currently operationally compatible to Great Lakes fleets and trades? What adaptations may be necessary?

The standard design for the Siemens SiCURE™ Ballast Water Management System uses sea water as a source of supply to produce sodium hypochlorite. However, the electrolytic cells in the SiCURE™ system are installed in a side stream of the main ballast intake, and just a fraction of the ballast water flow is required to produce sufficient sodium hyplochlorite to treat the main ballast flow. This opens opportunities for the adaptation of the Siemens' SiCURE™ system for the range of Great Lakes-relevant fleets. Canadian laker and salty vessels have access to salt water over the course of their voyage pattern to serve this purpose. Siemens has designed a system that allows ships to take salt water onboard while operating in salt water, store it in a designated ballast tank and use this water to feed the electrolytic generator during the ballast operation.

U.S. lakers never ply salt water. However, the SiCURE™ design can be customized to use salt water from an alternative source, not the incoming or stored onboard ballast water. For the vessels with trade routes limited to the Great Lakes boundaries, the applicability of the SiCURE™ will be subject to availability of this alternative source of salt for the side stream.

While Siemens does not expect the SiCURE™ system to raise corrosion issues, Siemens will be completing its corrosion testing program under the supervision of Germanischer Lloyds and in cooperation with ThyssenKrupp and International Paint in the second half of 2010. A circumstance of no interior coating on the ballast tank will be taken into consideration in this evaluation.

The SiCURE™ system can be used for medium to high ballast water flow ranges. With respect to the shorter voyage durations, the system may be modified for this application.

2. What is the general cost of the SiCURE™ system?

SiCURE™ Ballast Water Management System will be offered at a list price range from about U.S. $500,000 to U.S. $1.000.000 depending on size and configuration (prices given for 200 m^3/h and 2000 m^3/h systems).