THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

Ballast Treatment Systems

Prepared for
State of Washington / Puget Sound Action Team
Olympia, Washington

File No. 06017.01
August 2006

1201 Western Avenue, Suite 200, Seattle, Washington 98101-2921 | TEL 206.624.7850 | FAX 206.682.9117 | www.glosten.com

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William L. Hurley
Principal-in-Charge

Kevin J. Reynolds
Project Engineer

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BALLAST WATER TREATMENT SYSTEMS

References

1. Telephone Interview with Mr. Rudy Matousek, Severn Trent De Nora, 18 May 2006, 1:30 pm PST.

2. Telephone Interview with Mr. Matt Granitto, Hyde Marine Inc., 23 May 2006, 1:00 pm PST.

3. Telephone Interview with Mr. Peter McNulty, NEI Treatment Systems, LLC, 18 May, 9:30 am PST.

4. Telephone Interview with Ms. Hongwon Kim, Techcross Inc., 13 June, 5:00 pm PST.

5. Telephone Interview with Mr. Joel Mandleman, Nutech 03, 16 June, 10:00 am PST.

Introduction

The Glosten Associates were tasked by the Puget Sound Action Team to support Washington State Ballast Water Workgroup with an investigation of ballast water treatment systems. The goal of this effort was to determine which systems show promise of meeting Washington State regulatory requirements and to provide this information to the Workgroup supporting their report to the Washington State Legislature. The Glosten Associates conducted interviews with companies engaged in development and testing of such systems. We discussed the current state of development, particulars of each application, and cost data with several vendors of ballast water treatment systems. A standard set of questions was asked of each vendor. The results of these inquiries are presented herein.

The vendors were selected from a world-wide search using the International Maritime Organization (IMO) listing of treatment systems. The selection of the five vendors interviewed in this report was based on their prominence in the field which was measured by their testing activity, actual installations, and sound technology.

Treatment system capability is measured by the ballast water flow rate that the particular system is capable of treating. Different ship types typically have different ballast system flow rates, with tankers having high (~12,000 gpm or 2,800 m^3/hour) rates and passenger vessels low rates (~1,500 gpm or 350 m^3/hour). Systems are evaluated for flow rate capability which leads to an assessment of ship type suitability.

1. Severn Trent De Nora - BalPure™ Electro-chlorination

1.1 Development Status

- **Current state of development and timeline for commercial release of the technology:**

Severn Trent De Nora state that they are currently ready to commercially supply units of BalPure™ pending shipboard testing. Their present challenge is seen to be in finding a vessel and operator for a full-scale installation and testing.

- **System testing and regulatory review and certification:**

Severn Trent De Nora's BalPure™ claims 99% efficacy at 5 to 7 parts per million of chlorine. They are working on American Bureau of Shipping (ABS) Type Approval and have Naval Research Laboratory, Key West, testing in progress.

1.2 Application and Vessel Interface

- **Vessel types which the system is expected to serve:**

BalPure™ can treat brackish water and sea water with ease. Lean brackish water (lower than 15 grams/liter of salt) and fresh water can be serviced with the addition of salt. One million gallons of fresh water needs the addition of 1 ton of salt (approx. one 700 gallon tank). This system suits all types of vessels, and can be sized for all flow rates, however, it is seen by the vendor as most cost competitive for ships requiring large flow rates.

- **Vessel mechanical interfaces:**

Seawater to be treated at 5 PPM chlorine		Power Required	Unit Dimensions			Unit Weight
M^3/Hour	GPM	AC KVA	L (M)	W (M)	H (H)	Kg
400-825	2200	35	5.8	1.7	2.5	4200
826-1250	4400	52	5.8	1.7	2.5	4400
1251-1800	6600	78	6.5	1.7	2.5	4600
1801-2200	8800	103	6.5	1.7	2.5	4900
2201-2600	11000	110	6.9	1.7	2.8	5100
2601-3600	13200	165	6.9	1.7	2.8	5400

1.3 Commercial Issues

- **First cost to vessel Owner for various system flow rates and tank capacities:**

A base unit with an output of 1000 m^3/hour would have an initial equipment cost of $400,000. About $100,000 to $150,000 installation cost would be required for a retrofit install, or $60,000 to $70,000 for installation on a new ship build installation.

- **Operating cost to vessel Owner for various system flow rates and tank capacities:**

A total operating cost for BalPure™ is estimated to be $ 0.03/m^3, including power, sulphite neutralizer and replacement parts.

- **Service availability and network:**

Severn Trent De Nora's service network is worldwide and includes all major port cities. They feel that they can service ships nearly anywhere in the world, either shoreside or shipboard.

- **Lead time to receive unit from date of order placement:**

The Severn Trent representative estimated the current lead time to be 18 to 22 weeks, either for a single unit, or a multiple unit order, depending on the availability and wait time for steel (currently about 14 weeks) to produce the units.

2. Hyde Marine – Hyde Ballast Water Treatment System Ultraviolet radiation plus Filtration

2.1 Development Status

- **Current state of development and timeline for commercial release of the technology:**

Hyde Marine's HBWTS is available for commercial sale. There are currently six full-scale installations on various types of vessels including: cruise ships, a chemical tanker and container ship. The most recent installation and newest version is installed on the *Coral Princess* of Princess Cruises, a member of the Carnival family of cruise lines.

- **System testing and regulatory review and certification:**

The Hyde Ballast Water Treatment System installed aboard the Coral Princess has been granted approval for use in all State of Washington Ports by the Department of Fish and Wildlife. An application to the USCG for admission into STEP (Shipboard Technology Evaluation Program) is also currently being reviewed and expected to be accepted by late summer. The system is designed to meet the IMO 'D2' standard and once an acceptable test protocol has been approved for ballast systems, Hyde Marine will submit the system for approval.

2.2 Application and Vessel Interface

- **Vessel types which the system is expected to serve:**

The Hyde system is applicable to all vessel types and with all seawater salinities and can be sized to suit the specific vessel, depending on space and power limitations.

- **Vessel mechanical interfaces:**

Capacity in M^3/Hour	Capacity in GPM	Dimensions in Feet	Electrical Load in kW
250	1100	6 x 6 x 4	24
500	2200	12 x 6 x 4	48
1000	4400	12 x 12 x 4	96

System pressure drop through the treatment system is typically less than 5 psi. Booster pumps for back flush of filters can be installed to reduce this loss.

2.3 Commercial Issues

- **First cost to vessel Owner for various system flow rates and tank capacities:**

Capacity in GPM	Initial Equipment Cost
1100	$164,000
2200	$249,000
4400	$463,100

Installation costs are estimated by Hyde to be $5,000 for a new build and $15,000 for a retrofit.

- **Operating cost to vessel Owner for various system flow rates and tank capacities:**

Maintenance and replacement cost are limited to the consumables in the UV unit. The lamps should be changed out every 2 to 3 years. The replacement bulbs are roughly $400 each. Every 5 to 6 years all internal parts should be replaced at a rough cost of roughly $550 per lamp.

- **Service availability and network:**

A worldwide service network is available for Hyde products.

- **Lead time to receive unit from date of order placement:**

The Hyde representative stated 8 weeks as the lead time to place an order for the treatment system. Hyde's production capacity will be about 20 units in the first year and is expected to double in the next year.

3. NEI Treatment Systems
Deoxygenation via Venturi Oxygen Stripping

3.1 Development Status

- **Current state of development and timeline for commercial release of the technology:**

The NEI treatment system is now available for commercial sale. By late 2006 they will have two full-scale installs, one on the container ship *APL Japan* and the other on the *Mary Ann Hudson*, a Teco Ocean Shipping bulk carrier.

- **System testing and regulatory review and certification:**

NEI is in the application process for STEP testing and hope for IMO certification through Singapore.

3.2 Application and Vessel Interface

- **Vessel types which the system is expected to serve:**

The length of the process for Venturi oxygen stripping (5 days) will limit the application to ships that have transits of at least that duration. Large ships serving transoceanic routes are best suited to this technology. Passenger ships are not well suited to this treatment system. All salinities of water can be treated by this system. Fresh water processes at a slightly slower rate than brackish or salt water.

- **Vessel mechanical interfaces:**

Capacity in M^3/Hour	Dimensions in mm L	W	H	Electrical Load in kW (RUN / RATED)	Fuel in L/Hour	Unit Weight in Kg
1000	4000	1200	2300	25 / 45	100.0	2500
2000	4500	1500	3000	40 / 75	200.0	3000
3000	4800	1800	3300	50 / 90	300.0	3500
4000	5200	2000	3600	65 / 115	400.0	4500
6000	5600	2700	3900	100 / 180	600.0	5900
10,000	6400	3500	4600	150 / 220	1000.0	6200

3.3 Commercial Issues

- **First cost to vessel Owner for various system flow rates and tank capacities:**

NEI expects the average equipment cost of a moderately sized system to be $350,000 with installation costs averaging $60,000.

- **Operating cost to vessel Owner for various system flow rates and tank capacities:**

Diesel fuel comprises 100% of the operating cost. The NEI system comes with a one year service maintenance warranty while critical spare parts are covered for two years. The cost of filters and parts for the system is reported to be neglible.

- **Service availability and network:**

NEI has established a worldwide network for both sales and service of their treatment system.

- **Lead time to receive unit from date of order placement:**

Currently, the lead time for building an NEI system is reported to be 6 months, though order turn around time is expected to be faster in the future. A 3 month lead time is estimated to be the quickest possible for this system.

4. Techcross Inc. – Electroclean Electrolysis

4.1 Development Status

- **Current state of development and timeline for commercial release of the technology:**

Techcross has completed lab and pilot testing for their Electo-Clean system. They anticipate onboard testing to commence in June.

- **System testing and regulatory review and certification:**

Techcross has gained IMO "basic" approval and is now awaiting final approval from IMO, which they anticipate receiving by July of 2007.

4.2 Application and Vessel Interface

- **Vessel types which the system is expected to serve:**

Electro-Clean system states an ability to serve any type of vessel in any water salinity.

- **Vessel mechanical interfaces:**

This system is designed with a 1.6m x 1.8m x 1.5m foot print for a 200 m^3/hour unit. A 200 m^3/hour unit is expected to require 6 to 7 kW of energy use while a 500 m^3/hour unit will require 26 kW of power.

4.3 Commercial Issues

- **First cost to vessel Owner for various system flow rates and tank capacities:**

Initial cost for this system is still to be determined. Installation costs are expected to be around $50 per m^3/hour treatment.

- **Operating cost to vessel Owner for various system flow rates and tank capacities:**

Operating cost information was not available.

- **Service availability and network:**

Under development

- **Lead time to receive unit from date of order placement:**

8 weeks

5. Nutech 03
Venturi Ozone

5.1 Development Status

- **Current state of development and timeline for commercial release of the technology:**

After undergoing extensive testing and development of a distributed piping ozone system on the ST *Tonsina*, Nutech is currently installing a venturi version on the ST *Prince William Sound*. It is their stated objective to complete this installation and initial testing in the immediate future.

Nutech 03 has stated that the system will be ready for commercial sales in September of 2006.

- **System testing and regulatory review and certification:**

The ST *Prince William Sound* installation completion is expected this summer, in a Singapore shipyard. This installation has been reviewed to marine regulations and approved by the American Bureau of Shipping and the U.S. Coast Guard. Testing of the system is planned to commence upon vessel re-delivery in Singapore, through its transit to the U.S. West Coast and finally while in service on the U.S. West Coast.

Nutech 03 is working with the Korean government for submission of the system to IMO for active substance discharge review, as per the IMO G8 Guidelines. In the future, Nutech will be seeking ABS Type approval.

5.2 Application and Vessel Interface

- **Vessel types which the system is expected to serve:**

The technology has been designed for a range of vessels from 25,000 ton deadweight cargo ships through the largest tank vessels. The system has been tested in seawater, but not yet in freshwater.

- **Vessel mechanical interfaces:**

The single installation on the *Prince William Sound* handles a flow rate of 15,000 gallons per minute. The installation requires a piping modification to install the system venturi. In addition, significant electrical demand and modifications are required. Installation can be assisted by separating the equipment into 3 to 4 pieces.

5.3 Commercial Issues

- **First cost to vessel Owner for various system flow rates and tank capacities:**

Initial cost of a system similar to the *Prince William Sound* is estimated between $600,000 - $700,000 (15,000 gpm).

- **Operating cost to vessel Owner for various system flow rates and tank capacities:**

The cost for consumables, belts, compressors and chillers are estimated at $16,000 - $80,000 each maintenance interval. Operating costs (fuel consumption) has not been estimated.

- **Service availability and network:**

Nutech 03 is currently negotiating a sales and service network.

- **Lead time to receive unit from date of order placement:**

Nutech 03 has indicated a lead time of 8 weeks.

6. Vendor Comparison Table

Manufacturer, Name and Type of System	State of Development	Regulatory certification	Vessel type served	Seawater treated per hour and power usage	Cost: Initial	Cost: Installation	Cost: Operating	Service availability	Required lead time
Severn Trent De Nora BalPure™ Electro-chlorination	Commercially available Pending full-scale trials Pending certification	• ETV (NRL) in progress • ABS Type Approval pending	Ships requiring large flow rates	500 m^3/hour at 35 kW 1000 m^3/hour at 52 kW 3000 m^3/hour at 165 kW	Small capacity *Cost not reported* Medium capacity $400,000 Large capacity *Cost not reported*	$150,000 for retrofit $70,000 for new build	$0.03 / m^3	Worldwide	18-22 weeks
Hyde Marine Ballast Water U/V plus Filtration	Commercially available Pending full-scale trials Pending certification	• STEP application pending • California state testing in process • Washington state approved	Any	250 m^3/hour at 24 kW 500 m^3/hour at 48 kW 1000 m^3/hour at 96 kW	Small capacity $164,000 Medium capacity $249,000 Large capacity $463,100	$15,000 for retrofit $5000 for new build	Replacement U/V bulbs, $400 each every 2 to 3 years Internal parts, $550 per lamp every 5 to 6 years	Worldwide	8 weeks
NEI Treatment Systems Deoxygenation via Venturi Oxygen Stripping	Commercially available Pending full-scale trials Pending certification	• STEP application pending	Large ships serving transoceanic routes	500 m^3/hour *Power usage not reported* 3000 m^3/hour at 90 kW 10,000 m^3/hour at 220 kW	Small capacity $200,000 Medium capacity $350,000 Large capacity $1,000,000	$60,000 for retrofit *Cost for new build not reported*	Cost of diesel fuel	Worldwide	12 to 24 weeks
Techcross Inc. Electro-Clean Electrolysis	Have completed pilot testing Pending onboard testing	• Have received IMO basic approval • Awaiting IMO final approval, expected July 2007	Any vessel or water type	200 m^3/hour at 7 kW 500 m^3/hour at 26 kW	Under development	$50 per ton	*Cost not reported*	*Under develop-ment*	8 weeks
Nutech 03 Venturi Ozone	Commercially available by Sept. 2006 Pending full-scale trials Pending certification	• ABS installation approval	25,000 ton cargo ships to largest tankers	15,000 gpm *Power usage not reported*	$600,000 to $700,000 for large capacity system	*Cost not reported*	$16,000 to $80,000 service period Cost of diesel fuel	*Under develop-ment*	8 weeks