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Maritime Conferences

• The Maritime Environment •

International Conference and Exhibition

"Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports"

12st – 14st September 2001
Best Western Hotel Naber
Bremerhaven, Germany

The Conference is conducted under the Patronage of
Herr Josef Hattig
Senator for Economy and Ports, Freie Hansestadt Bremen

Freie Hansestadt Bremen

The Conference is sponsored by:

DEERBERG SYSTEMS

The Conference is supported by
Office of Naval Research International Field Office, London, UK

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14. ABSTRACT
The Maritime International Conference on ?Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports? held in Bremerhaven, Germany on 12-14 September 2001 was cosponsored by Deerberg-Systems, Germany, and by the U.S. Navy Office of Naval Research International Field Office. The conference objectives were: *To provide a forum for representatives from industry, ship owners, academia, governments, maritime and harbour authorities and shipyards for discussion and exchange of information on policies, trends and development of regulations for the treatment of ballast water, waste waste and sewage on ships and in ports *To discuss the management aspects related to waste water and ballast water treatment. *To present and discuss technologies and equipment for the treatment of black, grey and oily water as well as ballast water and sewage generated on board of ships. *To present and discuss advanced treatment technologies, future research and adaptation of current and future technologies for ship systems and *To make recommendations for latest technology applications on ships and in ports as well as for policies and internatiional collaboration.

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Maritime Conferences

· The Maritime Environment ·

Welcome to the Conference on

Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports

Conference Schedule

The Conference is conducted under the Patronage of
Herr Josef Hattig
Senator for Economy and Ports

Freie
Hansestadt
Bremen

The Conference is sponsered by

DEERBERG SYSTEMS

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Office of Naval Research International Field Office, London, UK

12th – 14th September 2001
Best Western Hotel Naber, Bremerhaven, Germany

Wednesday, 12th September 2001

08.30 - 09.30	Check-in and Welcome Coffee
09.30	Introduction by the Conference Organiser
09.45	Welcome by the Mayor of Bremerhaven, Oberbürgermeister Jörg Schulz
10.05	Keynote Address by Staatsrätin Sybille Winther, Senator for Economy and Ports, Freie Hansestadt Bremen

Introduction

10.30 - 11.00	The Alaska Regulation for the Cruise Industry - a Glimpse of the Future ***Dr. Michael A. Champ***, ATRP Corp., US

Session 1 — Ballast Water

11.00 - 11.30	Ballast Water Management (Author: Lefteris Karaminas) ***Ramona Zettelmaier,*** Lloyds Register, GE ***Marcel Paetzold***, Lloyds Register, GE
11.30 - 12.00	Management Options for Ballast Water Operations ***Session Chairman Dr. Matthias Voigt***, Environmental Consultant, GE
12.00 - 13.30	**LUNCH**
13.30 - 14.00	Survival of Species in Ships Ballast Water ***Dr. Stephan Gollasch***, GOConsult, GE
14.00 - 14.30	Evaluation and Optimisation of Ballast Water Treatment ***Capt. Christian Bahlke***, GAUSS, GE
14.30 - 15.00	Environmentally Sound and Effective Ballast Water Treatment by Peraclean Ocean – Results of Practical Tests ***Dr. Rainer Fuchs***, Degussa, GE
15.00 - 15.30	OptiMar Ballast System – A Practical Solution for the Treatment of Ballast Water on Ships ***Birgir Nilsen***, OptiMarin, NO
15.30 - 16.00	Different Vessels, Different Treatments? Possibilities and Constraints for Ballast Water Treatment in Different Vessel Types ***Franca Sprong-Wijnreder,*** IWACO B.V., NL
16.00	**COFFEE**
17.00	**Bus Sightseeing Tour of the Seaport City of Bremerhaven offered by the City of Bremerhaven**
19.00	**Reception by the Senator for Economy and Ports, Freie Hansestadt Bremen aboard the Sailing Vessel SEUTE DEERN**

Thursday, 13th September 2001

08.30 - 09.00	Chances for Strangers in Ballast Water ***Capt. Cornelius de Keijzer***, Port Authority Rotterdam, NL
09.00 - 09.30	Latest Developments on International Ballast Water Management Initiative at IMO ***Steve Raaymakers***, IMO, UK
09.30 - 09.45	Discussion
09.45 - 10.15	**COFFEE**
Session 2	**WASTE WATER AND SEWAGE TREATMENT**
10.15 - 10.45	Sewage onboard Ships - Policies and Regulations ***Klaas Jan Bolt,*** Ministry of Public Works, NL
10.45 - 11.15	Black Water Pre - Treatment and Real Situation on Board ***Holger Hamann,*** Hamann Wassertechnik, GE
11.15 - 12.00	Using Immersed Membrane Bioreactor Technology The MEMROD Project – Progress and Experience ***Steffen Richter***, VA-TECH WABAG, GE ***Manuel Finner***, W B I, GE ***Olaf Petersen***, GAUSS, GE
12.00 - 12.30	Grey Water Purification and Black Water Treatment on Board of Cruising Ships with ROCHEM Technology ***Dr. Thomas Peters*** on behalf of ROCHEM UF Systeme GmbH, GE
12.30 - 14.00	**LUNCH**
14.00 - 14.30	The Optimisation of Membrane Bioreactor Technology for Use in the Treatment of Marine Waste Water ***Alan Smith,*** Hamworthy KSE, UK
14.30 - 15.00	Bio Cleaning and Waste Treatment Products meet the Environmental Challenge ***Margaret V. Hepburn,*** Hepburn Bio Ship Care, MC
15.00 - 15.30	Use of Natural Micro-Organisms for Black and Greywater Systems ***Bryan Spencer***, United-Tech. Inc., US
15.30 - 16.00	**COFFEE**
16.00 - 16.30	Retrofitting Shipboard Grey & Blackwater Treatment Systems ***Session Chairman John Klie***, Zenon Environmental Inc, CA
16.30 - 17.00	The Optimal Solution for Liquid Waste Treatment onboard Ships - Black Water and Grey Water ***Dr. Gerhard Schories,*** DEERBERG-SYSTEMS, GE
17.00	Presentation of the Activities of the Lloyd Werft Bremerhaven GmbH ***Dipl.-Ing. Werner Lüken***, Managing Director, Lloyd Werft Bremerhaven GmbH, GE
18.30	**Cocktails / Dinner hosted by DEERBERG-SYSTEMS, GE** Guests of honour for the evening: Dipl.-Ing. Werner and Christa Lüken Managing Director, Lloyd Werft Bremerhaven GmbH

Friday, 14th September 2001

08.30 - 09.00	Redesigning and Refurbishing Noncompliant Shipboard Treatment Plants ***Gerry. F. Maloney***, MPI International, US
09.00 - 09.30	Membrane Bioreactors for Treating Black, Grey and Bilge Water on Shore and off Shore ***Lex van Dijk***, Triqua, NL
09.30 - 10.00	State of the Art and Development Trends in Centrifugal Bilge Water Treatment ***Dr. Rainer Witte,*** Westfalia Separator Mineraloil Systems, GE
10.00 - 10.30	How to Handle the Bilge Water Cocktail ***Session Chairman Valentijn Korteling***, PROMAC B.V., NL
10.30 - 11.00	**COFFEE**
11.00 - 11.30	Progress of Sewage Treatment Technology onboard German Navy Vessels – Frigate F 124 vs. Sailing Training Ship GORCH FOCK ***Michael Neubold***, BWB, GE
11.30 - 12.00	Separation of Solids and Liquids ***Hen Boele***, Solits bv, NL
12.00 - 12.30	Waste Water Management (Handling, Disposal, Treatment) ***Aad Hoek***, AVR Maritiem, NL
12.30 - 12.50	Discussion
12.50	Summary and Conference Conclusions by Mr. Klaus Eule
13.00	**LUNCH**
14.00	**Departure**

Exhibitions

BETECH Engineering, BE, Willy Vanderpoorten, Guido Everaerts

DEERBERG - SYSTEMS, **GE**, Jochen Deerberg, Dr. Gerhard Schories

Petrol Rem Inc., USA, Dr. Michael A. Champ

Zenon Environmental Inc, CA, John Klie, Minggang Liu, Adam Kaminski

Welcome address by the Conference Organizer, Mr. Klaus D. Eule, to the Conference on "Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports"*

Frau Staatsraetin Winther, Herr Oberbürgermeister Schulz, Ladies and Gentlemen!

Welcome to Bremerhaven!

and - Welcome to our Conference on "Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports"

Before we start our conference let me express our sympathy to our American friends for the tragedy that has been inflicted on them.
Let us pay our respect to the thousands of innocent people who lost their lives in this cruel and cowardly act of terrorism in the United States yesterday.
Please let us stand for a moment of silence and prayer. – Thank you.

I would like to extend a special welcome and our thanks to our Sponsors:

- the Senator for Economy and Ports of the Hanse City of Bremen represented here by Frau Staatsraetin Sybille Winther,
- Mr. Jochen Deerberg, the CEO of the Total Waste Management Systems company DEERBERG-SYSTEMS based in Oldenburg, not far from here,
- the US Navy Office of Naval Research International Field Office in London and last but not least
- the active support we are getting from the City of Bremerhaven, represented here by its Mayor, Mr. Jörg Schulz.

Bremerhaven, as many of you know, is one of the major German seaports belonging to the Hanse City of Bremen. All different trades of the maritime industry are located here, whether it is the Shipping Industry with several shipping lines, a major shipyard, or the fishery industry. You will see more of the City and its Port during a tour later this afternoon, which has been offered by the City of Bremerhaven - many thanks in advance.

We are certainly very proud that we are holding the conference here, as we know that Bremen and Bremerhaven for many years have undertaken major efforts in the area of environmental protection of our ports, sea and shores.

The Senator of Economy and Ports of the Hanse City of Bremen will be our host tonight for the reception aboard the Sailing Vessel "Seute Deern". The reception will start at 19.00 after the city tour.

In the world of maritime application of waste management systems DEERBERG-SYSTEMS is a well known company and the world-wide leading supplier for Total Waste Management Systems for the Cruise Line Industry. DEERBERG-SYSTEMS now has been supplying over 115 systems to large passenger vessels. Mr. Deerberg will host our dinner tomorrow night. We will inform you of the details during today's meeting.

The US Navy Office of Naval Research International Field Office is committed to fostering and facilitating collaboration in Science, Technology, Research and Development between the United States and their professional counterparts in Europe, Africa and the Middle East. The US Navy Office of Naval Research International Field Office is linked with international scientists and engineers through conferences, workshops, visits and personal research to identify key opportunities in Science & Technology, to assess Science & Technology activities and accomplishments and to exchange information and ideas in areas of mutual interest.
The US Navy Office of Naval Research International Field Office is based in London.

This conference will deal with the subjects of ballast water on the one hand and waste water on the other hand.
In view of tightening regional legislation and controls in many ecologically sensitive areas of the world the treatment and cleansing of waste water before pumping it overboard has become a technological and industrial issue. The problem is not that the industry does not have the technology of how to do it in principle – it is done every day in every small town's sewage treatment plan. The problem is the large amount of water on a passenger ship to be treated in a very short time with a guaranteed cleanliness due to the limited bunker capacity of the ships.

The other problem, which will be our first subject, is the increasing awareness of the dangers associated with the import of ballast water and its biological content from foreign sea areas in our home ports. This has created a demand for science and industry to develop technologies or processes to treat these huge amounts of water before it is pumped into our ports. Regulation Authorities are already discussing new restrictive regulations, which will make treatment mandatory.

We have selected the papers for our conference with the intention to contribute knowledge and examples and to provide an expert forum for discussion of these matters involving the regulatory authorities as well as the concerned industry.

Therefore the objectives of this conference are:

- To provide of a forum for representatives from industry, ship owners, academia, governments, maritime and harbour authorities and shipyards for discussion and exchange of information on policies, trends and development of regulations for the treatment of ballast water, waste water and sewage on ships and in ports.
- To discuss the management aspects related to waste water and ballast water treatment.
- To present and discuss technologies and equipment for the treatment of black, grey and oily water as well as ballast water and sewage generated on board of ships.
- To present and discuss advanced treatment technologies, future research and adaptation of current and future technologies for ship systems and
- To make recommendations for latest technology applications on ships and in ports as well as for policies and international collaboration.

We again have some companies, like during the past conferences, exhibiting their products. Our exhibitors are DEERBERG-SYSTEMS from Germany, Zenon from the United States, BETECH from Belgium and Petrol Rem Inc. From the United States.

I recommend that you take the opportunity to get yourself informed on the products and visit the stands.

The exhibitor`s teams will certainly answer all your questions and provide you with the latest information on their products.

Finally, I would like to introduce to you my colleague Mrs. Elke Lonicer, our Conference Manager, who all of you have already met or talked to on the telephone.
Elke and I will be available to you during this conference and assist you in any matters, where you feel, that we could be of help. So, please do not hesitate to call on us for assistance. I will have some more administrative remarks before we break for lunch.

I would now formally pass the word to Herrn Oberbürgermeister Jörg Schulz from the City of Bremerhaven for his welcome remarks to the conference and after that we will have the honour of Frau Staatsraetin Sybille Winther to open the conference on behalf of the Hanse City of Bremen.

CURRICULUM VITAE

Michael A. Champ

Dr. Michael Champ received his academic degrees from Texas A&M University with major course work in animal science, biochemistry, biology, chemistry, toxicology, veterinary science, limnology, marine science, fisheries, oceanography, statistics, and environmental engineering with a dissertation on organic and inorganic carbon cycles. Next he held a NSF Fellowship in the Oceanography Department at TAMU and worked in the Antarctic on the Ecology of the Ross Sea Project and was also the Radiation Safety Officer for USNS Eltanin Cruise No. 51. He has served in the following positions in the private and public sectors, in academia, industry, and the U.S. Federal government:

- From the early 70's to mid 80's, he was a Professor and Director of Environmental and Marine Sciences at the American University in Washington, D.C.

- In the mid 70's, he served as the Resident Scholar of the U.S. Army Corps of Engineers Board of Engineers for Rivers and Harbors, a congressional oversight board for all U.S. water resource projects - for construction of locks and dams and port facilities for review of all projects prior to submission to Congress. In this position, he was involved in the environmental and cost benefit review of coastal and inland waterway projects from dredging to construction of port facilities.

- From 1979 to 1984, he served as a Resident Scholar to the National Oceanic and Atmospheric Administration in the NOAA R&D Office of Marine Pollution Assessment and in the Ocean Assessments Division and was responsible for the review and preparation of environmental assessments (EA and EIS) and R&D related to ocean disposal of municipal, industrial, dredged materials and nuclear wastes.

- From 1984-1986 he served as a Senior Science Advisor at the U.S. Environmental Protection Agency (EPA) in the Office of Policy, Planning & Evaluation. He was responsible for the development and review of environmental permits, audits, assessments and registration of hazardous and toxic chemicals. He was involved in the Special Review of TBT as used in as a biocide in antifouling boat bottom paints and was extensively involved in writing the U.S. Organotin Act for Congress.

- From 1986 to 1989, he held several positions at the National Science Foundation (NSF). In 87-89, he was a Program Director for Industry/University Cooperative Research Centers and Engineering Research Centers in the Division of Cross-Disciplinary Research in the Engineering Directorate. Prior to that, he was a Senior Advisor at NSF to develop a new U.S. initiative in Ocean Engineering for the exploration and development of ocean resources in the new U.S. Exclusive Economic Zone (EEZ). He received a commendation from President Reagan for assisting in the writing of the U.S. Exclusive Economic Zone (EZZ) Proclamation and the creation of the Ocean Enterprise Concept.

- Between 1989 and 1993, Dr. Champ served as a part-time consultant to Research & Development at Pacific Gas & Electric Company in San Francisco, California for a wide range of research projects from environmental assessments associated with advanced renewable energy technologies to the design and development of multi-year R&D strategic plans, and management strategies. He served as one of PG&E's senior peer reviewers for engineering and environmental research associated with the development of advanced energy [fossil, nuclear, and renewable (PV, Solar, Wind, Wave, & Energy Storage)] technologies, conducted in house and by external consultants.

- From 1989 to 1997, he was a senior scientist and directed the Geochemical and Environmental Research Groups (GERG) Washington, D.C. Office, which became the Texas Engineering Experiment Station's Washington, D.C. Office for Texas A&M University. In this period he was associated with bringing in to Texas A&M University over $ 50 M of environmental research to Texas A&M University. From 1993 to 1998, he was a senior PI in the Office of Naval Research ANWAP funded $ 30 M assessment of contamination in the Russian Arctic.

- From 1991 to 1996 served as a part-time consultant to the Marine Spill Response Corporation's (MSRC) Research and Development Division in Washington, D.C. At MSRC, he was extensively involved in the design of R&D and interpretation of results, preparation of reports and development oil spill contingency plans, which use Best Response. In 1993, he was requested to serve as a founding editor and is currently the Editor-in-Chief of the international journal: *Spill Science & Technology Bulletin* published by Elsevier Science in Oxford, England.

- In January 1998, the Advanced Technology Research Project (ATRP) was incorporated in Virginia with Dr. Champ as President and CEO. It was endorsed by U.S. Senate Resolution and joint declaration of members of the U.S. House of Representatives and the Russian Duma in cooperation with Texas A&M University and the University of Alaska. The ATRP serves to help corporations and governments assess environmental risks and evaluate alternatives, and optimize operations in a comprehensive system-based context to identify and integrate all relevant variables, constraints, and required information related to decision-making in the utilization of advanced environmental technologies.

Review of R&D

Michael Champ has been significantly involved in the design and review of marine and environmental research programs in government, academia and the private sector, and the preparation and review of environmental assessments, environmental impact statements and environmental and human health risk assessments. He has extensive experience in experimental design and the delineation of the hypotheses to be tested, in both process oriented and environmental effects research. He has extensive marine contaminant experience associated with research related to the Potomac River and Chesapeake and Delaware Bays and for municipal and industrial ocean dumping at North Atlantic Ocean Dump Sites. For over 30 years, he has been involved in the validation of laboratory and field predictive studies to predict short and long-term effects of toxic and hazardous materials spilled or discharged into aquatic and marine environments. He currently serves on NSF, ONR, DOD, EPA, NOAA, NSF, and SBIR (innovative technology) peer review panels for review of government, industry and academic research.

While at the National Science Foundation (NSF) Dr. Champ was involved in the development of U.S. national centers of excellence. These R&D centers have been created at the major U.S. universities in a wide range of scientific and engineering disciplines. Today there are over 60 such centers, which have been established in a major effort by the U.S. to regain international competitiveness in engineering, science and technology. These centers utilize the interactive strategic planning processes to identify critical research agenda's to design and direct national research programs. These strategic planning processes utilize decision and factor analysis mechanisms to evaluate the cost effectiveness and economic benefits of different research pathways and approaches proposed to solve identified questions and/or test hypotheses. To the nation, the benefits of these efforts were the development of protocols for establishing the most cost effective research approach (cost/unit time) maximizing resources.

Oil Spill Response R&D

From 1991 to 1996 served as a consultant to the Marine Spill Response Corporation (MSRC) Research and Development Division in Washington, D.C. At MSRC, he was extensively involved in the design of R&D and interpretation of results and international oil spill contingency planning and response and the review and synthesis of data and information from MSRC funded R&D projects. He is also a founding editor and currently the Editor-in-Chief of the international journal: *Spill Science & Technology Bulletin* published by Elsevier Science in Oxford, England. A major book on "Oil Spills: Science, Policy and Law" is to be published in early 2000. The focus of this Elsevier Science book is to expand the use of science in the oil spill response decision-making process. It has been developed from the Technology Windows-of-Opportunity" Concept, which provides a common foundation for the development of a rapid and cost effective tool for oil spill contingency planning and spill response decision-making. The intended USER will be state and federal agencies, response planners, clean up organizations (responders), insurance companies, tanker owners, transporters and students.

Contamination & Environmental Assessments

From the early 60s, Dr. Champ has studied the major rivers and estuaries of the U.S. and Europe. During the 70s and 80s, he was extensively involved with ocean discharge and ocean dumping of radioactive, municipal and industrial wastes at nearshore and deep ocean dump sites in the U.S., and Europe. With over 100 papers in this area, he has studied most of the major industrial or municipal ocean dumpsites in the world. At the COE, DOD, NOAA and EPA, he has contributed to the preparation and review of hundreds of environmental assessments or environmental impact statements. As the Resident Scholar of the Board of Engineers for Rivers and Harbors (COE Congressional Oversight Board), he was part of the environmental review of all COE projects during the Carter Presidency. At EPA, his office was at CEQ (722 Jackson Place) and he was extensively involved in the NEPA national debate and the review of the National Pollution Discharge Elimination System (NPDES) for discharge permits. From 1990 to 1996, he served as a part-time consultant to the Orange County Sanitation Districts, California for the design of its 5- year ($ 10 M) ocean waste discharge and outfall research and monitoring program and subsequent interpretation of results. Dr. Champ is a member of the editorial board of the *Marine Pollution Bulletin*, and currently holds an appointment as Senior Research Scientist at the University of Alaska in Fairbanks. He has held academic and/or research appointments at the American University, VIMS (BLM OCS), University of Hawaii (Natural Energy Institute of Hawaii - Ocean Energy and Mariculture), Texas A&M University (GERG and TEES), University of Alaska (Office of Arctic Research).

In 1999, Dr. Champ received a grant from ONR, EPA and the State of Virginia (DEQ) through the Center for Applied Ship Repair and Maintenance (CASRM) to organize and coordinate an international symposia on the "Treatment of Regulated Discharges from Shipyards and Drydocks" held at the Oceans '99 meeting in Seattle Washington. The goals of this meeting were to conduct a global review and to create opportunities for technology transfer of waste treatment methods used in shipyards to treat ship washdown wastewaters to remove TBT, Cu and other biocides. He is a consultant to CASRM for Quality Assurance (QA/QC) and to assist in the development and operation of the CASRM Barge Mounted TBT Treatment System for shipyards.

Arctic Contaminants

Between 1993 and 1998, he was a co-principal investigator with the Office of Naval Research (ONR) multi-year funded ANWAP Project (Assessment of Nuclear Wastes in the Arctic) on nuclear and industrial contaminants released to the Arctic from Russian marine and land based sources. His GERG research cruises have covered the Russian Arctic from the Barents Sea to the East Siberian Sea. These cruises have sampled every major river and estuary in the Russian Arctic. With ONR funding, as the lead editor, he published in 1997 the first volume of two of the *Marine Pollution Bulletin* on "Contaminants in the Arctic" (for marine sources) and has in press a special issue of *CHEMOSPHERE* on "Contaminants in Terrestrial and Aquatic Watersheds of the Russian Arctic" (for land based sources) to be published in early 2000.

Environmental "Double Good" Technologies

In the mid 1980's, Dr Champ became interested in environmental technologies which were "Double Good" Technologies from which both environmental and economic benefits were derived. These technologies solved an immediate environmental regulatory problem. An example would be DAF – for the separation of organics for discharge permits, which would after a period of time save a company money by either sale of a recoverable product or reduced the level of water treatment needed such as aeration or carbon filtration. The concept for these advanced technologies developed from consulting at PG&E where public utility power plants were receptive to new environmental technologies if they lowered operating costs. In addition these power plants were looking for ways to reduce costs by unique environmental cooperative businesses such as adding fish farms to down stream warm water discharges as a tradeoff for the costs of cooling towers.

Ocean Space and Resources R&D

Dr. Champ's interest in ocean space and ocean resources expanded when he was at the National Science Foundation (NSF). He was involved with the development of ocean systems engineering and the development of interests at NSF for the development of ocean space and ocean resources. Jim Dailey (B&R), David Ross (WHOI) and Mike Champ were the fathers of the Ocean Enterprise Concept and organized in 1989 the NSF funded "Ocean Enterprise Workshop" and several others since then related to use of ocean space and resources, including the 1991 NSF sponsored workshop on "Engineering Research Needs for Off-Shore Mariculture Systems" at the University of Hawaii. He has extensive experience in mariculture, cage culture, ocean thermal energy conversion (OTEC), and ocean technologies associated with developing ocean resources in Japan, Korea and Taiwan.

Dr. Champ is interested in determining the economic and environmental values of ocean space and resources. He has published over 100 papers related to the use of ocean space and the development of ocean resources. Including assessment of ocean values and economics, and the assessment of the environmental impacts from very large floating ocean structures (VLFS). In 1996, he presented the first paper assessing the potential engineering, environmental and social impacts from very large floating structures which was published by the Japanese Ship Research Institute in the Proceedings of the Second International Workshop on Very Large Floating Structures, Nov. 25-28, 1996, Hayama, Japan. In September (22-24, 1999), he co-chaired the Environmental Risk and Impact Sessions at the third international VLFS Workshop. Currently he is a consultant to ONR to assess the environmental risks and effects of VLFS. He is currently an environmental consultant to ONR for the MOBs (Mobile Offshore Bases) Program

International R&D

Dr. Champ was a member of the first U.S. Scientific and Engineering Delegations to visit the Peoples Republic of China, and has written three papers on the status of environmental pollution and research and development activities in China. As a Queens Fellow in Marine Science in Australia, he organized and co-edited the special issue of Oceanus (the International Magazine of Marine Science and Policy published by the Woods Hole Oceanographic Institution) on "The Great Barrier Reef: Science and Management." Dr. Champ also organized and edited the special issue of Oceanus on the "U.S. Exclusive Economic Zone." In 1986, he served as guest editor of a special issue of Sea Technology Magazine on "Environmental Monitoring" and in 1987 for the special issue on "Ocean Engineering and Resource Development." Since 1980, Dr. Champ has participated in most of the UJNR (U.S. Japan Joint Meetings for Marine Facilities Panel here in the U.S. and in Japan. From the beginning, he has been involved in the development of the Ocean Platforms Conferences through the University of Hawaii. He has extensive experience in mariculture, ocean thermal energy conversion, and ocean technologies in Japan, Korea and Taiwan. Dr. Champ has conducted and published research in Australia, Canada, Germany, the United Kingdom, Russia, China, Japan, Korea, and Taiwan.

Honors and Awards

Over the past twenty years, he has served as chairman for nine national and international special technical symposia, each dealing with some aspect of materials and or processes that occur in the environment, pollution, and waste treatment. The papers presented at these symposia have been published as 6 special volumes of the IEEE and Marine Technology Society's International Ocean's Conferences, 5 books and 7 special issues of international journals. In 1984, Dr. Champ was honored for his contributions in marine science by being designated a Senior Queen's Fellow for Marine Science in Australia. The Marine Technology Society advanced Dr. Champ to the rank of Fellow for his contributions to the advancement of the Society's objectives and for accomplishments in marine science, and technology in 1987. President Ronald Reagan in 1984 singled out Dr. Champ for his leadership and contributions to the U.S. EEZ Proclamation.

PUBLICATIONS

Dr. Champ has authored over 300 scholarly publications, including 5 books, in the fields of limnology, oceanography, marine and environmental science, pollution, waste treatment, science policy and technology.

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The New Alaska State Regulations for Cruise Ships and Subsequent Consequences for the Global Cruise Ship Industry and Shipping in General

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Summary

This paper is an attempt to summarize in one document, the new Alaska State regulations for Cruise ships and subsequent consequences for the global cruise ship industry and the shipping industry in general. It is not a status report, its purpose is to review the legislation and the subsequent regulation and to give the reader a simple overview of what has been proposed and why. It is a summary of actions taken to date with the results to come, which will be posted on the excellent ADEC web site: A series of ADEC reports summarize over time the activities of the four work groups and their numerous reports. The specific details of their work, including the minutes of all the meetings, will be available on the ADEC web site
http://www.state.ak.us/dec/press/cruise/cruise.htm

The Cruise ship legislation and discharge and emission regulation in Alaska developed because the State of Alaska does not have standard port facilities to receive and process ship wastes. In addition, a second key factor is that a major portion of the Alaskan population to a large degree lives off subsistence hunting and/or fishing of marine resources as food sources. The commercial fishers off Alaska are valued annually over 3 billion US dollars and it is estimated that over 70 % of the people in the State of Alaska are employed in some aspect of the fisheries industry.

The Cruise ship industry is constantly looking for remote and pristine environmental places to visit to expand its business. The Cruise line industry's modus of operandi for visiting pristine environmental areas is to provide maximum day light (shopping or sightseeing) time for tourists in ports and/or areas adjacent to tourist visitation sites. This places the Cruise ship (as a hotel) for an 8-10 hour period or more in or near valuable coastal marine resources that tourists wish to see.

In time, every state or nation that wishes to protect their marine resources will adopt the Alaska State regulations. In the near future, as more states and nations develop marine desalination operations to provide citizens with a high quality drinking water from the cooling waters of electric power generation plants, all ships will be facing discharge and emission regulations. By 2010, all developed nations will have such regulations for ships in global commerce. The onset of these regulations in Alaska could have been delayed by perhaps 10-15 years, by installing at Federal and State expense shore based waste treatment facilities, which would have been

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significantly cheaper than retrofitting 700 Cruise ships or 30,000 ships in global commerce with waste treatment systems over the next 15 years.

INTRODUCTION

Alaskans (native and indigenous) have become very concerned about how the cruise ship tourist industry could be impacting air and marine coastal environments, and what the industry is doing to control, treat and mitigate the wastes it creates. During the past decade, the size and number of cruise ships frequenting Alaska's coastal waters have increased dramatically. Approximately 237,000 passengers visited Alaska in 1990, and 632,000 are expected during the 2000 season. Ports such as Ketchikan and Juneau may host as many as five large cruise ships and several smaller ones a day.

Pollution from Ships

Under certain atmospheric conditions, State environmental agencies have received reports of cruise ship stack air emissions being highly visible, persistent, and causing reduced visibility. Concern about pollution from ships especially discharges and their potential impacts on water quality and aquatic resources such as salmon were heightened when one cruise line pleaded guilty to discharging hazardous wastes, such as photo processing wastes, with graywater over a period of years in Alaska waters. Additionally, marine pilots reported ships going to dumping grounds referred to as "doughnut holes" (locations in the Inside Passage more than three miles from land) to discharge ship board wastes. In Alaska, large cruise ships operating carry up to 1500 tonnes (405,000 gallons) of heavy, persistent fuel oils. Prior to May 2000, the Cruise Line and the vessels did not have formal OSRO agreements with an oil spill response action contractor in Southeast Alaska.

Several key issues or concerns escalated these pollution problems:

- The development of waste treatment systems for ships is more of a technology development of the last 10-15 years and has in particular been related to new construction with some retrofitting in the Cruise ships industry.
- The State of Alaska unlike any of the lower US 49 States does not have port facilities to offload wastes from ships, which is in direct violation of MARPO and its Annexes which require and define shore facilities to treat wastes.
- A large portion of the citizens of Alaska live from subsistence hunting and fishing, and were concerned that there food sources were at risk of being contaminated by the waste discharges from the Cruise industry which was predicted to grow to over 1 million visitors a year.

Actions Taken by the Cruise Ship Industry

The cruise ship industry has recently implemented a number of progressive, continuously improving management systems and new technologies that should prevent this pollution concerns. The Cruise industry has been one of the most successful (richest) components of the shipping industry. Nevertheless, the industry being fully appreciative of the importance and value to the Cruise ship tourist industry that the coastal environmental resources (whales, birds, aesthetics of the coastal landscape, the glaciers and marine life in general) in Southeastern and Central Alaska quickly became committed to address all problems that arose from ship operations. Some of the improved management systems measures include new wastewater treatment systems, continuous on-board air emissions monitoring, recycling programs, and environmental care programs for crew and passengers. Cruise ships are subject to international standards set by the International Maritime Organization, the Classification Societies (e.g., Lloyds Register, Norske Veritas), the flag states, as well as U.S. and Canadian laws when in those waters and ports. The cruise lines operating in Alaska agreed to additional voluntary measures for environmental protection that go beyond strictly complying with the current national and international laws. The Cruise ship industry being fully aware and appreciative of experiences in Alaskan and US courts regarding decisions related to restoration of pristine marine and coastal areas following environmental impacts such as the *Exxon Valdez* have been very cooperative.

US Federal and Alaska State Agencies Responsible for Pollution Prevention from Ships

Several agencies are responsible for implementing environmental programs designed to prevent and control pollution. Agency responsibilities for cruise ship operations in this regard are:

- U.S. Coast Guard for spill prevention and response, marine sanitation device certification and proper operation, oily waste treatment and discharges, hazardous materials handling.
- U.S. Environmental Protection Agency for air quality, water quality, and hazardous waste management.
- Alaska Department of Environmental Conservation for air quality, water quality, spill prevention and response, and waste management.

The Alaska Department of Environmental Conservation asked the U.S. Coast Guard, the U.S. Environmental Protection Agency, and the Southeast Conference (a group representing Southeast Alaska communities) to join cruise ship industry officials in this discussion of ways to improve controls on cruise ship pollution. The Cruise ship industry is also represented by several organizations, which are discussed below.

STATE OF ALASKA REGULATIONS (House Bill 260)

House Bill 260 establishes the commercial passenger vessel environmental compliance program under the Alaska Department of Environmental Conservation (ADEC). It authorizes the establishment of terms and conditions for the discharge of wastewater, including limitations and prohibitions on the discharge of wastewater, record keeping requirements, sampling and testing, vessel access, and submission of certain records, notices, and reports.

Applicability

The program applies to vessels carrying passengers for hire with overnight accommodations for at least 50 passengers, but tailors wastewater discharge limitations and prohibitions to the size of the vessel. Because the smaller vessels (between 50 and 249 overnight berths) pose less risk to the environment and are physically limited with respect to the use of current technology for treating and holding waste, the larger vessels (250 or more overnight berths) are generally held to stricter requirements.

Registration

Prior to entering Alaska waters each year, vessels subject to the program must register with ADEC. For each owner and operator of a vessel, the registration must include its business name and contact information; the name and address of an agent for service of process, located in Alaska; the name and port of registry for each affected vessel; and its agreement, under oath, to comply with the terms and conditions specified in the bill.

Wastewater Discharge Standards

The following Standards have been developed:

- **Untreated Sewage:** Passenger vessels are prohibited from discharging untreated sewage, i.e. sewage that has not met all applicable federal processing standards and effluent limitation standards. This means that sewage must be processed through a properly operated and maintained marine sanitation device and meets the applicable effluent standards.
- **Treated Sewage:** Sewage cannot be discharged if it has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters. Small vessels can delay compliance upon submission of a plan that provides interim protective measures.
- **Graywater:** Graywater cannot be discharged if it has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters. Vessels can delay compliance upon submission of an interim plan.
- DEC can establish numeric and narrative standards by regulation for any other parameters for treated sewage and graywater, including chlorine, chemical oxygen demand, and biological oxygen demand.

Restrictions on Discharges

Large vessels may not discharge treated sewage or graywater unless the vessel is proceeding at a speed of not less than six knots and more than one nautical mile from shore, complies with effluent standards, and is not in a no-discharge zone. Small vessels are not subject to this provision. Large passenger vessels are excused from compliance if the discharges are proven to meet strict secondary treatment standards.

Exceptions to Standards and Restrictions

The prohibitions and limitations do not apply to discharges made for the purpose of securing the safety of the ship or saving life at sea so long as all reasonable precautions are taken to prevent or minimize the discharge. DEC is authorized to set alternative terms and conditions on a case-by-case basis for owners and operators of vessels that cannot practicably comply with the standard terms and conditions or that wish to test alternative environmental protection equipment or procedures.

Reports, Sampling, and Testing

Vessels must provide reports detailing wastewater discharges, take samples of such discharges, test those samples, and provide the results. Other reports are required for hazardous and solid waste. Sampling and testing requirements may be met by providing the state with substantially equivalent information collected to comply with federal law or the law of another state. DEC is also permitted to collect its own samples of treated sewage or graywater that is being discharged into state waters.

Vessel Access

Vessels must allow state access for sampling and verifying the integrity of the sampling process.

Environmental Compliance Fund

Fees are collected from cruise vessels to pay for the state's costs of implementing the program. The fee is graduated, reflecting the amount of overnight accommodation capacity, and amounts to about one dollar for each lower berth for each voyage.

A commercial passenger vessel environmental compliance fund – consisting of fees, certain penalties collected under the program, money appropriated by the legislature, and earnings on the fund – is established and funds are available to the legislature for appropriation to pay for the program's operational costs. The fund can be used to monitor vessels, including air quality testing, as well as to monitor and study environmental effects of discharges and research ways to reduce those effects.

Environmental Leadership

DEC is authorized to encourage and recognize superior environmental protection efforts by the vessels.

Enforcement

Enforcement provisions are the same as those for any other violation of state environmental statute.

STATE OF ALASKA ACTIONS

Four working groups were chartered by the leaders of the "Steering Committee" to undertake fact finding on air emissions, wastewater discharges, waste disposal management, oil spill prevention and response, and environmental leadership. In a series of open meetings between February and May 2000, these work groups endeavored to:

- Identify the waste streams and spill risks from cruise ships that could impact Alaska's air and water resources;

- Develop pollution prevention and waste management solutions, including better technology and management practices, that will eliminate or reduce impacts;
- Assess what process is needed to verify compliance; and
- Keep Alaskans informed.

Achievements

Industry members, government agencies and citizen's groups have produced a number of recommendations, agreements, protocols, reports, and procedures to address the four above objectives. These work products include:

- An agreement for air monitoring in downtown Juneau during the 2000 cruise ship season, including analysis of sulfur dioxide, particulate matter and nitrous oxides.

- Random, third party wastewater analysis of all cruise ships throughout the 2000 season.

- A survey of waste stream discharges and solid waste handling practices for all cruise ships operating in Alaska.

- Proposals and pilot projects from industry for a number of new technologies; including, ultra-filtration of graywater, cleaner "green" diesels and gas turbines, non-toxic dry-cleaning processes, and more effective oily-water separators.

- Charter of a small scientific work group to develop criteria for selecting "sensitive areas" where the discharge of treated blackwater and graywater will be controlled through location and vessel speed, or voluntarily prohibited.

- While the above work is underway, develop a new, voluntary, wastewater discharge plan for cruise ships in 2000 that is designed to minimize wastewater impacts. Large cruise ships will voluntarily secure or prohibit wastewater discharge within 10 nautical miles of their course to last and next ports of call. Discharges will occur at a minimum speed of 6 knots. [Note: There is no scientific research to show that 10 miles is the appropriate distance; however, this figure will be used until research shows a different appropriate distance.]

- Approval of a maintenance and operations plan for eight new oil spill recovery barges that have been contracted by North West Cruise Ship Association for deployment throughout Southeast Alaska in 2000.

- Development of regional priorities, concepts and guidance to ensure continued acquisition of the most cost-effective oil spill response equipment.

- Agreement on the essential elements of environmental leadership and the formation of a sub-committee to pursue a cruise ship environmental leadership program for Alaska.

- Development of a public information document that summarizes the cruise ship industry's environmental management system in layman's terms.

- Cruise Ship Environmental Awareness Day(s) in July 2000, designed to allow the industry, regulatory agencies and citizen's groups to listen, learn, and educate. (Co-sponsored by the industry, ADEC, Coast Guard, Southeast Conference, and EPA.).

Recommendations

The working group recommended that the Steering Committee:

- Endorse the funding arrangements for the downtown air-monitoring plan for immediate implementation.

- Approve the wastewater sampling protocol for immediate implementation.

- Comment on the cruise industry's voluntary wastewater discharge plan.

- Disband the Oil Spill Work Group formed under this initiative with the understanding that its activities will be continued under the Southeast Alaska Sub-area Oil Spill Contingency Planning Committee.

- Approve the recommendation to create a sub-committee that will develop a long-term environmental leadership program.

- Support Cruise Ship Environmental Awareness Day(s) and assist the environmental leadership work group in their efforts to involve community leaders outside of Juneau.

Cruise ship Air Emissions Working Group

Developed a plan for a cost-effective analysis of ambient air quality in downtown Juneau during summer 2000, which includes:

<u>Monitoring</u>:
- Operation of a sophisticated ambient air urban trend monitor (on loan for 30 days from EPA, subject to approval from EPA headquarters);
- Installation and operation of three particulate matter monitors and one sulfur dioxide monitor; and
- Operation of a downtown meteorological station.

<u>Emission Control Strategies:</u>
The industry reports that efforts are continuing to identify and implement technology to reduce air emissions and the impacts of those emissions; including:
- Current practices:
    - Use of medium speed diesels
    - Experimenting with changes in operations (e.g., operating two of four engines when safe operations permit)
    - Use of IFO (Intermediate Fuel Oil) 180 instead of IFO 380 or 780,

    - Continuing to search for the best quality, lowest sulfur fuels available.
    - Prohibiting the use of incinerators in port.
    - Attention to timing and maintenance to achieve optimum combustion.

- Promising technology and future plans:
    - "Green" diesel engines on new vessels and possible retrofit for existing vessels. "Green" diesels utilize fuel injector systems similar to those installed on late model automobiles. In addition, injected steam more effectively atomizes fuel to achieve near 100% combustion.
    - Gas turbine engines on new vessels that burn light diesel with fewer emissions per kilowatt produced when compared to the intermediate fuel oil currently used.
    - Research into fuel cells capable of providing power in port.

- Safety during maneuvering:
    - Both state marine pilots and cruise ship operators have expressed the concern that ships might feel a pressure to maneuver for emissions minimization rather than safety. Work Group notes that Alaska State statutes allow temporary excursions of opacity standards for the purpose of maneuvering. It was never the intent that safe operation of vessels should be compromised to meet opacity standards.

- Future plans:
    - Implement the air quality analysis plan as described above;
    - Prepare and widely distribute an end of season report explaining the air quality information gathered;
    - Review the end of season report and determine whether additional activity is necessary, including the possibility of similar monitoring efforts in other communities;
    - Track the results of several independent opacity monitoring efforts (smoke reading);
    - Through the Environmental Leadership Work Group, publicize and promote new technologies and operational procedures that will reduce emissions on ships.

Cruise Ship Water Discharges and Solid Waste Working Group

The overall objective of the Work Group on Wastewater and Solid Waste is to assess the nature and extent of wastewater and solid waste discharges from cruise ships in Alaska so the public, government, and industry will have the best possible information to make decisions concerning these discharges.

Fact finding and Analysis

- A contractor was retained to assemble information on the type and quantity of discharges from cruise ships. The contractor's report, *A Survey of Waste Stream Discharges and Solid Waste Handling Practices of Cruise Ships Operating in Southeast Alask*a, provides a brief description of waste stream handling methods and lists new technology that may minimize the impact of waste discharges.

- The contractor's survey is only the first step in an effort to quantify the impact of discharges from cruise ships. Determining the water quality of these discharges is the next step. Wastewater quality will be monitored during the 2000 Alaska cruise ship season through an extensive collaborative sampling effort between the industry, Coast Guard, ADEC, and citizen's groups. The scope of work and sampling plan developed for this effort is attached as Appendix D, the *Cruise Ship Wastewater Monitoring Protocol for 2000 in Southeast Alask*a. Highlights of the plan include procedures for:
  - Random, unannounced sampling;
  - Analysis of conventional pollutants;
  - Analysis of priority pollutants; and
  - Oversight by Coast Guard inspectors.

Changes in operational practice or technology to minimize impacts

- Currently, cruise ships do not discharge graywater or treated blackwater in port. However, discussions have revealed that "in-port" has various definitions among marine operators. The cruise ship industry is developing general consensus definitions of "in-port" and "underway". These definitions will be terms that can be used worldwide, while still incorporating the unique nature of Alaska operations.

- The cruise industry has committed to working with federal, state and local agencies to identify especially sensitive areas where wastewater discharges should be avoided. This will be an on-going dialogue but an initial list of especially sensitive areas will be developed for this season.

- The industry reports that efforts are continuing to identify and implement technology to reduce the amount of waste generated and to reduce the impacts of waste that is discharged including:
  - Graywater filtration systems that can remove up to 90% BOD. Two ships will be outfitted with these systems in the summer of 2000.
  - Effective and efficient digital photo technology or other technologies to reduce hazardous waste stream generation during photo processing.
  - Alternative dry cleaning processes such as CO_2 and "wet" processes.
  - Recycling laundry water to reduce graywater discharge.
  - Use of non-toxic based printing ink, non-chlorinated solvents and other non-hazardous products to eliminate the hazardous wastes in print shops.
  - Oily water separators that produce effluents with less than 5 ppm oil.

Future plans

- Implement the random, unannounced wastewater sampling and analysis program for the 2000 season.
- Report the results of the sampling and program.
- Develop a list of especially sensitive areas where discharges should be avoided.

Cruise Ship Oil Spill Work Group

The large cruise ships operating in Alaska carry up to 1500 tonnes (405,000 gallons) of heavy, persistent fuel oils. Prior to May 2000, these vessels did not have an in-region response capability should a pollution incident occur. In addition, the oil transportation industry's spill response equipment in Southeast Alaska was designed for highly refined products, primarily diesel, which would not effectively recover the higher viscosity oils. The North West Cruise Ship Association (NWCA) is constructing four sets of paired oil spill recovery barges for pre-positioning throughout Southeast Alaska. As the result of a settlement with the State of Alaska, a cruise line is providing nearly $2.5 million in response equipment and geographic response strategy planning.

By forming alliances with local oil spill response contractors, the Cruise ship industry will make a significant, positive impact on improving the pollution response capabilities of the region. To that end, an oil spill work group was formed from members of cruise industry, the United States Coast Guard, Alaska Department of Environmental Conservation, the Northern Lynn Canal Nearshore Project and the Southeast Alaska Petroleum Resource Organization (SEAPRO). The work group's goals were:

- To assist in standardizing equipment,
- To provide input for pre-planning,
- To work towards agreements on multi-party use,
- To identify equipment shortfalls for future planning.

The work group decided to divide the work into two phases. The first phase involved a series of discussions that focused on:

- Regional response needs,
- Capability and deployment of the response barges being provided by North West Cruise Ship Association (NWCA),
- Recommendations and guidance for equipment to be provided by a cruise line under the terms of a settlement agreement with the State of Alaska.

NWCA Oil Response Barges: Construction is underway on four-paired response barges (eight barges total) systems for open water recovery systems. The barges will be positioned in four locations in Southeast Alaska. The first pair was delivered to Glacier Bay on May 7, 2000. All barges will be pre-positioned by September 2000. The capabilities of each pair is:
Recovery capacity: Lori brush inclined plane skimmer rated for 700 barrels/hour (29,400 gals/hour)
Temporary storage: 250 barrels per barge, 500 barrels (21,000 gals) total
Boom: 2000 feet per pair, 1000 feet of 20-inch boom per barge
Work boat: 3700 pound skiff that can be launched and retrieved through an on board davit system.
Tow speeds: up to 20 knots to the scene, around 8 knots loaded

NWCA barge Management Plan

SEAPRO developed a management plan for NWCA barges. The work requested that SEAPRO include the barges in its basic ordering agreement (BOA) with the Coast Guard. A BOA is a contractual arrangement that allows the Coast Guard to quickly mobilize and hire SEAPRO for a federally funded clean up.

Cruise Line/State Settlement

Members of the Work Group had an extended discussion regarding the type of equipment that should be provided as part of the $2,100,000 supplemental environmental project required by a cruise line settlement with the State of Alaska. The Work Group decided not to develop a specific list of equipment needs, believing it was more appropriate to set criteria for response capability. Ten concepts and priorities for equipment selection were developed:

1. Manageable out-year operation and maintenance costs.
2. Best coverage for cruise ship operating areas.
3. Independent response capability (self-contained response system).
4. A 6-hour on-scene response time for higher risks areas.
5. Capability for shoreline protection.
6. First response capability for wildlife protection.
7. Ability to perform a number of functions (most capability for the cost)
8. Ability to use in both persistent and non-persistent oil spills.
9. Shallow water response capability.
10. Compatibility with the existing Southeast Alaska response inventory. Specific equipment and the timeline for delivery will be an outcome of on-going discussions between ADEC and the cruise line.

Northern Lynn Canal Nearshore Response Project

ADEC has worked with the communities of Haines and Skagway, the Northern Southeast Local Emergency Planning Commission, SEAPRO and the USCG to position response equipment in northern Lynn Canal. In March, ADEC, the Haines Borough, and the Cities of Haines and Skagway signed an agreement to procure spill response equipment that will be positioned in Haines and Skagway. Equipment procured by the Nearshore project includes two 21-foot work skiffs, 3000 feet of 30” boom, and other materials which together with a 55-foot long gull-wing design response barge, a skimmer, and a large transfer pump procured using a portion of the Cruise Line/State settlement forms a complete recovery system. The barge will be of a standard design capable of holding 249 barrels (10,500 gal) of oil, allows for sufficient deck space for response operations, has power rollers for boom deployment, and room on deck for a 21-foot work skiff.

Environmental Leadership Work Group

Environmental leadership is an emerging approach to integrate environmental stewardship into the business management practices of an organization. It is a continuing process that achieves environmental excellence through employing prevention based environmental systems and environmental accounting. Organizations move beyond mere compliance with existing regulations by establishing an environmental management system that incorporates pollution prevention into the core business philosophy and practices. Every business, community, citizen and ultimately the environment will benefit. The overall goal of the Environmental Leadership Work Group is a clean Alaska environment. The establishment of a sustainable system for long-term environmental excellence and leadership will help achieve that goal.

The Alaska Regulation for the Cruise Industry - a Glimpse of the Future

Michael Champ

ATRP Corporation

Falls Church, Virginia

Bremerhaven Germany

Sept 12-14, 2001

JUNEAU, Alaska:

June 29, 2001, Governor Knowles signed a Bill from the State Legislature with strong public backing making Alaska the first State to regulate water pollution from cruise ships.

Background:

- More than 680,00 cruise ship passengers are expected to use the Alaska's Inside Passage this Season (Summer, 2001).
- North West Cruise Ship Association, representing the nine major cruise companies doing business in Alaska, supported the bill.

Cruise Ships in Juneau Harbor

Background:

- The legislation culminated almost two years of voluntary initiatives and cooperative relationships with legislators and administration officials, state and federal regulations, environmentalists and communities.

Justification/Need:

- Alaska only US State to ***NOT*** have Shore Based Waste Treatment Facilities.
- Second - Subsistence Food Sources.

Alaskans Concerned About:

- How the cruise ship industry is impacting air and water and,
- What the industry is doing to control and mitigate the wastes it creates.
- Two Cruise Ship Companies were convicted in 1999 of violations.

Pollution Threat:

- Under certain atmospheric conditions, cruise ship stack air emissions have been highly visible and caused reduced visibility.
- Concern about ship discharges potential threat to salmon fisheries enhanced when one cruise line pleaded guilty to discharging photo processing wastes with graywater over a period of years in Alaska waters.

- **Additionally, Marine pilots reported ships going to "doughnut holes" (locations in the Inside Passage more than three miles from land) to discharge wastes.**
- **Large cruise ships operating in Alaska carry up to 1500 tons (405,000 gallons) of heavy, persistent fuel oils.**
- **Prior to May 2000, Cruise ships did not have formal agreements with oil spill response clean up contracts in Southeast Alaska.**

Why Alaskan's Reacted Swiftly:

- Small & Unique Population <500,000.
- Fishing is the major industry.
- No major heavy industry.
- Most pollution land-based from military (Cold War) and oil industry.
- Exception - oil spills.

Historical Perspective:

- Dramatic Tourist Industry Growth - Appox. 237,000 passengers in 1990 to 632,000 in 2000 Season. (3x in decade).
- Ports such as Ketchikan and Juneau may host as many as five large cruise ships and several smaller ones a day.

The Bill:

- Which he championed reflects "that Alaskans take environmental protection as seriously as they take salmon fishing and tourism."

- Affects ships capable of carrying 50 or more overnight passengers, sets up a monitoring and sampling program for water and air emissions and solid waste.

The Bill:

- Targets treated sewage and "graywater," or runoff from sinks, showers, kitchens, laundries, and other non-sewage sources.
- Establishes Standards for allowable discharges in state waters and it sets up a $ 1 USD per passenger fee to fund enforcement by the State Department of Environmental Conservation (ADEC).

Requirements:

- The Law goes into Effect 7/2/2001.
- It Requires at least a Summer of Monitoring and sampling (2001) to develop some of the regulations limiting wastewater emissions.

The Bill Establishes:

- The <u>Commercial Passenger Vessel Environmental Compliance Program</u> under ADEC.
- Establishes terms and conditions for the discharge of wastewater, including limitations and prohibitions on the discharge of wastewater, record keeping requirements, sampling and testing, vessel access, and submission of certain records, notices, and reports.

Applicability

- The program applies to vessels carrying passengers for hire with overnight accommodations for at least 50 passengers, but tailors wastewater discharge limitations and prohibitions to the size of the vessel.
- Because the smaller vessels (between 50 and 249 overnight berths) pose less risk to the environment and are physically limited with respect to the use of current technology for treating and holding waste, the larger vessels (250 or more overnight berths) are generally held to stricter requirements.

Registration

Prior to entering Alaska waters each year, vessels subject to the program must register with DEC. For each owner and operator of a vessel, the registration must include its business name and contact information; the name and address of an agent for service of process, located in Alaska; the name and port of registry for each affected vessel; and its agreement, under oath, to comply with the terms and conditions specified in the bill.

Wastewater Discharge Standards

Untreated Sewage:

•Passenger vessels are prohibited from discharging untreated sewage, i.e. sewage that has not met all applicable federal processing standards and effluent limitation standards.

•This means that sewage must be processed through a properly operated and maintained marine sanitation device and meet the applicable effluent standards.

Wastewater Discharge Standards

Treated Sewage:

- Sewage cannot be discharged if it has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters. Small vessels can delay compliance upon submission of a plan that provides interim protective measures.

Wastewater Discharge Standards

Graywater:

- Graywater cannot be discharged if it has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters. Vessels can delay compliance upon submission of an interim plan.
- **DEC can establish numeric and narrative standards by regulation for any other parameters for treated sewage and graywater, including chlorine, chemical oxygen demand, and biological oxygen demand.**

Restrictions on Discharges

- Large vessels may not discharge treated sewage or graywater unless the vessel is proceeding at a speed of not less than six knots and more than one nautical mile from shore, complies with effluent standards, and is not in a no-discharge zone.
- Small vessels are not subject to this provision. Large passenger vessels are excused from compliance if the discharges are proven to meet strict secondary treatment standards.

Exceptions to Standards and Restrictions

- The prohibitions and limitations do not apply to discharges made for the purpose of securing the safety of the ship or saving life at sea so long as all reasonable precautions are taken to prevent or minimize the discharge.
- DEC is authorized to set alternative terms and conditions on a case-by-case basis for owners and operators of vessels that cannot practicably comply with the standard terms and conditions or that wish to test alternative environmental protection equipment or procedures.

Reports, Sampling, and Testing

Vessels must provide reports detailing wastewater discharges, take samples of such discharges, test those samples, and provide the results. Other reports are required for hazardous and solid waste. Sampling and testing requirements may be met by providing the state with substantially equivalent information collected to comply with federal law or the law of another state. DEC is also permitted to collect its own samples of treated sewage or graywater that is being discharged into state waters.

Vessel Access

- Vessels must allow State of Alaska (ADEC) access for sampling and verifying the integrity of the sampling process.

Environmental Compliance Fund

- Fees are collected from cruise vessels to pay for the state's costs of implementing the program. The fee is graduated, reflecting the amount of overnight accommodation capacity, and amounts to about one dollar for each lower berth for each voyage.

- A commercial passenger vessel environmental compliance fund – consisting of fees, certain penalties collected under the program, money appropriated by the legislature, and earnings on the fund – is established and funds are available to the legislature for appropriation to pay for the program's operational costs. The fund can be used to monitor vessels, including air quality testing, as well as to monitor and study environmental effects of discharges and research ways to reduce those effects.

Environmental Leadership:

- DEC is authorized to encourage and recognize superior environmental protection efforts by the vessels.

Enforcement:

- Enforcement provisions are the same as those for any other violation of state environmental statute.

Reminder:

- **It is easy to regulate contamination -pollution from a <u>Private</u> & <u>Point</u> Source.**
- **Politics Roles Easiest Down Hill.**

Cruise Ship Industry Perspective:

- Recently implemented a number of progressive & continuously improving waste management technologies.
- New wastewater treatment systems, continuous on-board air emissions monitoring, recycling programs, and environmental care programs for crew and passengers.

- **The industry also notes that cruise ships are subject to a rigorous set of international and national laws and standards set by IMO, the Class Societies, the flag states, as well as U.S. and Canadian laws when in those waters and ports.**
- **Cruise ships operating in Alaska have agreed to additional voluntary measures for environmental protection that go beyond strictly complying with the laws.**

Regulatory Players in Alaska:

- **ADEC for air quality, water quality, spill prevention and response, and waste management.**
- **USCG for spill prevention and response, marine sanitation device certification and proper operation, oily waste treatment and discharges, hazardous materials handling.**
- **USEPA for air quality, and hazardous waste management.**

“Steering Committee”- Four Working Groups & Roles:

- Identify the waste streams and spill risks from cruise ships.
- Develop pollution prevention and better waste management solutions and practices.
- Determine processes needed to verify compliance
- Keep Alaskans informed.

Working Groups:

- Air Emissions Working Group
- Solid Waste Working Group
- Cruise Ship Oil Spill Working Group
- Environmental Leadership Working Group

Juneau Cruise Ship Monitoring – 2000

- DEC designed a monitoring program with the cruise ship industry and concerned citizens to measure the concentrations of sulfur dioxide, nitrogen dioxide, and fine particulates in downtown Juneau.
- The cruise ship industry (NWCA), through a third party contractor, managed three monitoring sites.

OPACITY MONITORING - Alaska Cruise Ship Initiative - *ADEC*

- Opacity is visible emissions from a smoke stack – in these cases, from a cruise ship. Opacity cannot be used to measure impacts on public health. Opacity is an aesthetic or quality of life issue.
- Opacity is measured by looking through smoke and determining how much of the background is obscured because of the smoke. Certified smoke readers attend a class, pass a written classroom test, and pass a semi-annual visible emission observation test.

- **DEC operates a fourth site on top of the Court Plaza building.**
- **Monitoring began August 13, 2000 and continued through September.**
- **Preliminary monitoring results indicate that the ambient pollution levels were below 45% of the ambient air standards.**

Table State of Alaska Air Quality Monitoring Complaints by Date, Ship and Port.

Date	Ship	Complaint	Port
5/2/2001	Norwegian Sky	Opacity	Juneau
5/7/2001	Zaandam	Opacity	Juneau
5/9/2001	Volendam	Opacity	Juneau
5/14/2001	Zaandam	Opacity	Juneau
5/21/2001	Not Stated	Opacity	Juneau
5/27/2001	Carnival Spirit	Opacity	Skagway
5/30/2001	Not Stated	Opacity	Juneau
6/1/2001	Universe Explorer	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/2/2001	Carnival Spirit	Opacity	Juneau
6/5/2001	Sea Princess	Opacity	Juneau
6/5/2001	Sea Princess	Opacity	Juneau
6/9/2001	Carnival Spirit	Opacity	Juneau
6/11/2001	Mercury	Opacity	Juneau
6/14/2001	Not Stated	Opacity	Juneau
6/17/2001	Mercury	Opacity	Juneau
6/19/2001	Regal Princess	Opacity	Juneau
6/19/2001	Sea Princess	Opacity	Juneau
6/20/2001	Volendam	Opacity	Juneau
6/20/2001	Not Stated	Opacity	Juneau
6/22/2001	Not Stated	Opacity	Juneau
6/22/2001	Crystal Harmony	Opacity	Juneau
6/22/2001	Sun Princess	Opacity	Juneau
6/25/2001	Mercury	Opacity	Juneau
6/25/2001	Seven Seas Mariner	Opacity	Juneau
6/28/2001	Sun Princess	Opacity	Juneau
6/30/2001	Carnival Spirit	Opacity	Juneau

7/3/2001	Not Stated	Opacity	Juneau
7/3/2001	Regal Princess	Opacity	Juneau
7/3/2001	Asuka	Opacity	Juneau
7/3/2001	Asuka	Opacity	Juneau
7/3/2001	Sea Princess	Opacity	Juneau
7/3/2001	Asuka	Opacity	Juneau
7/3/2001	Regal Princess	Opacity	Juneau
7/3/2001	Asuka	Opacity	Juneau
7/6/2001	Not Stated	Opacity	Juneau
7/12/2001	Not Stated	Opacity	Valdez
7/13/2001	Ocean Princess	Opacity	Juneau
7/14/2001	Carnival Spirit	Opacity	Juneau
7/14/2001	Not Stated	Opacity	Juneau
7/16/2001	Spirit of Oceanis	Opacity	Juneau
7/16/2001	Spirit of Oceanis	Opacity	Juneau
7/16/2001	Spirit of Oceanis	Opacity	Juneau
7/17/2001	Mercury	Opacity	Sitka
7/17/2001	Not Stated	Opacity	Juneau
7/17/2001	Regal Princess	Opacity	Juneau
7/17/2001	Sea Princess	Opacity	Juneau
7/17/2001	Sea Princess	Opacity	Juneau
7/17/2001	Norwegian Sky	Opacity	Juneau
7/17/2001	Sea Princess	Opacity	Juneau
7/17/2001	Regal Princess	Opacity	Juneau
7/17/2001	Norwegian Sky	Opacity	Juneau
7/17/2001	Regal Princess	Opacity	Juneau
7/17/2001	Sea Princess	Opacity	Juneau
7/21/2001	Not Stated	Opacity	Juneau
7/26/2001	Sun Princess	Opacity	Juneau
7/30/2001	Zaandam	Opacity	Juneau
7/30/2001	Ryndam	Opacity	Juneau
7/31/2001	Regal Princess	Opacity	Juneau
7/31/2001	Norwegian Sky	Opacity	Juneau
7/31/2001	Sea Princess	Opacity	Juneau
7/31/2001	Sea Princess	Opacity	Juneau
7/31/2001	Sea Princess	Opacity	Juneau
7/31/2001	Regal Princess	Opacity	Juneau
8/1/2001	Dawn Princess	Opacity	Juneau

8/3/2001	**Sun Princess**	**Opacity**	**Juneau**	
8/3/2001	**Sun Princess**	**Opacity**	**Juneau**	
8/3/2001	**Not Stated**	**Opacity**	**Juneau**	
8/7/2001	**Regal Princess**	**Opacity**	**Juneau**	
8/7/2001	**Norwegian Sky**	**Opacity**	**Juneau**	
8/7/2001	**Not Stated**	**Opacity**	**Juneau**	
8/9/2001	**Universe Explorer**		**Opacity**	**Valdez**
8/10/2001	**Not Stated**	**Opacity**	**Skagway**	
8/14/2001	**Not Stated**	**Opacity**	**Juneau**	
8/14/2001	**Norwegian Sky**	**Opacity**	**Juneau**	

Source: (Alaska Department of Environmental Conservation, 2000)

For Current Information in the future:

See:http.//www.state.ak.us/dec/press/cruise/cruise.htm

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”Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports”

Session 1

Ballast Water

Session Chairman: ***Dr. Matthias Voigt***
Environmental Consultant, GE

CURRICULUM VITAE

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CURRENT DUTIES & RESPONSIBILITIES

Basic Grade Engineer Surveyor in Hamburg Plan Approval Centre (HMD).
Responsible for machinery work in respect of plan approval of new constructions, existing ships and Type Approval.

CAREER SUMMARY

08.1989 - 10.1991	Sea service apprenticeship on chemical tanker and container vessels as multipurpose seaman (ship mechanician) at Deutsche Africa Linien shipping company and at Seemansschule Travemünde/Priwall
02.1992 - 06.1996	Studies at Technical University of Applied Sciences for Marine Engineering in Flensburg. Promoted to I. Engineer „CIW“ on deep sea motor/steam ships of unlimited power.
08.1996 - 02.2000	Sea service on motor container vessel as a 3rd and 2nd Engineer at Leonhardt & Blumberg shipping company.
02.2000	Joined Lloyd’s Register in February 2000, LR Hamburg Plan Approval Centre as Engineer Surveyor.

QUALIFICATIONS

ACADEMIC:

1992 - 1996	Fachhochschule für Schiffsbetriebstechnik Flensburg (University of Applied Science) Chief Engineers Licence for Motor/Steam Ships of unlimited power Diplom Engineer for Marine Engineering (Dipl.Ing)

PROFESSIONAL EXPERIENCE

Service with Lloyd's Register

02.02.2000 – 26.01.2001	Engineer Surveyor on probation to Lloyd's Register at Hamburg Plan Approval Centre (HMD)
02.2001 -	Engineer Surveyor to Lloyd's Register at Hamburg Plan Approval Centre (HMD)

Professional Experience prior to joining LR

08.1989 - 02.1992	Reederei Deutsche Africa Linien, Hamburg Sea Service as multipurpose engineering apprenticeship on chemical tanker, general cargo and container vessels
02.1992 - 05.1996	Studies of Technical University of Applied Sciences for Marine Engineering in Flensburg.
09.1996 - 02.2000	Reederei Leonhardt & Blumberg, Hamburg Sea Service as 3rd and 2nd Engineer Officer on container vessels (1600 – 4500 TEU)

June 2001

Abstract

Ramona Zettelmaier
Marcel Paetzold
Lloyd's Register, GE

"Ballast Water Management"
(Author: Lefteris Karaminas)

Ship owners, managers and builders will be aware that a number of port states including Australia, Canada, Chile, Israel, New Zealand and the USA have introduced regulations intended to prevent ships which arrive in their waters from discharging ballast water which contains “non-native, harmful species of aquatic lifeforms”. The masters of such ships are expected to demonstrate that they have taken steps to prevent such discharge by some means which is acceptable to the relevant port state.

LR carried out an investigation on the various ballast water management methods with particular emphasis on the risk of the sequential method. LR, prompted by the fact that issues pertinent to the sequential method have not yet been fully appreciated by the industry, commenced a two-part study using 26 existing ships of various types, configurations and sizes. The objective of the first part of the study was to investigate the effects of the sequential method on the ship’s structure and the assessment criteria in respect of classification, statutory and operational aspects. The objective of the second part of the study was the development of a safe operational envelope, on the basis of sea-keeping analysis, to control the dynamic effects for the ballast condition under consideration. Overall, the study serves as a reference guide for Administrations who intended to develop ballast water management policies. The investigation raises serious concerns for the safety of the most existing ship types and the configurations using the sequential method of ballast water exchange and options to mitigate such risks are discussed.

LR *Technical Association*

Ballast Water Management

by L. Karaminas, H. H. Ocakli, K. C. Mazdon and P. C. Westlake

Lloyd's Register

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Ballast Water Management

Synopsis

Ship owners, managers and builders will be aware that a number of port states including Australia, Canada, Chile, Israel, New Zealand and the USA have introduced regulations intended to prevent ships which arrive in their waters from discharging ballast water which contains "non-native, harmful species of aquatic lifeforms". The masters of such ships are expected to demonstrate that they have taken steps to prevent such discharge by some means which is acceptable to the relevant port state.

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Author

Lefteris Karaminas

Co-authors

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Paul Westlake

Table of Contents

1 Introduction

Ships that carry large quantities of a particular cargo are invariably forced to spend time at sea without any such cargo. To achieve a seaworthy condition in terms of stability, trim and strength, sea-water is taken on board to form the ballast condition, which is of a somewhat lighter displacement than the full load condition. For those ships carrying general cargo, partially loaded conditions are common and water ballast is also used to adjust trim, heel and stability of the ship to compensate for the non-homogeneous loading condition.

The International Maritime Organisation has estimated that every year the world's fleet moves ten billion tonnes of ballast water around the world and that on average more than 3000 species of plants and animals are being transported daily around the world. Once these are introduced to local environment, it is virtually impossible to get rid of them. This could have a permanent effect on the environment, which could bring a catastrophic effect on local fisheries. It is therefore imperative that introduction of harmful aquatic organisms is prevented rather than cured afterwards.

Whilst harmful aquatic organisms are also transported on the bottom of a biofouled hull and on the anchor chain cable, it would appear that the Administrations have decided to deal with the transfer of harmful aquatic organisms in ballast water. The Administrations perceive that the solution to this problem is ballast water management.

2 Ballast Water Management Methods

The ballast water management methods fall under three categories, the exchange, the treatment and the isolation of ballast water (fig. 1).

IMO currently recognises two ballast water exchange at sea methods, the sequential and the flow-through.

The sequential method is defined as when a ballast tank is emptied and refilled. When this method is utilised, the pumping and piping systems undergo an increased workload. The effective exchange of almost the complete volume of ballast water has resulted in the perception that the sequential method is an effective way of prohibiting the transfer of harmful aquatic organisms. However, this method requires careful planning and monitoring by the ship's staff to mitigate the risks imposed on the ship in respect of longitudinal strength, dynamic loads, excessive trim, bottom forward slamming, propeller emergence, intact stability and bridge visibility.

The flow-through method is defined as when replacement water is pumped into the ballast tank allowing the water to overflow. It has been reported that such a method could be effective only if the water pumped-in equals several times the volume of the tank. Approximate figures so far indicate a 95% and 98% water exchange after pumping-in water equivalent to three and four tank volumes respectively, assuming perfect mixing conditions. Some tank configurations, such as the double bottom and peak tanks, could be difficult to flush through effectively and may require pipework to improve mixing. Care is needed in the application of this method which could result in the resizing of pumps due to the increased resistance and higher workload, fitting of new pumping and piping systems, over-pressurisation leading to structural damage and icing on deck in sub-zero temperature conditions.

Research is currently conducted world-wide on the development of efficient and effective ballast water treatment methods. Some of the concerns regarding the treatment methods are as follows:

- Mechanical treatment:
  clogging of filters, not effective for small organisms, disposal of the collected residues, limited space on existing ships, resizing of the pumps may be required to cope with the increased filter resistance.
- Physical treatment:
  health and safety aspects for crew, additional pipework, adverse effect on tank coating, pipes and pumps which could lead to corrosion, discharge of heated water may be undesirable for environmental reasons.
- Chemical treatment:
  health and safety aspects for crew, limited space on existing ships, adverse effect on tank coating, pipes and pumps which could lead to corrosion, discharge of treated water may be undesirable for environmental reasons.

No treatment method has yet been recognised at international level. Whilst there are obvious financial gains for research companies investing in such methods, it may prove legislatively difficult for Administrations to identify individual products, unless there are clear standards against which these are assessed. A possible way ahead is by some kind of international type approval.

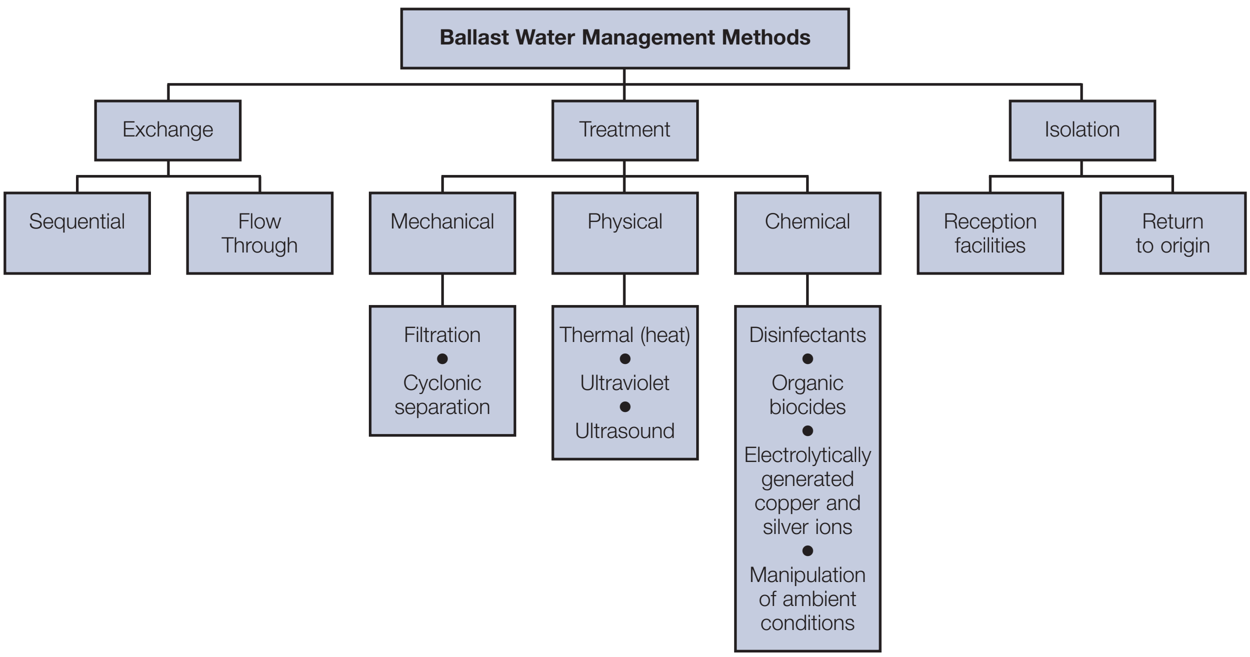


Figure 1 – Ballast water management methods

Discharging to reception facilities would avoid the problems of the exchange and the flow-through methods. However, this method could force most ships to spend more time at port with an associated workload increase in the piping and pumping systems.

Discharging to the location where ballast was taken in would be impractical in most cases, since retention on board is not feasible for all ship types, especially for deadweight carriers. This method could introduce additional time spent at sea.

3 Instigation of the LR Study

In November 1997, IMO, having regard to the safety implications for ships undertaking ballast water exchange at sea, published the *Resolution A.868(20), Guidelines for the Control and Management of Ship's Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens*.

These guidelines introduce the concept of a 'ballast water management plan' (BWMP), specific to each ship, which would contain information and guidance intended to provide safe and effective procedures for ballast water management, especially with regard to ballast water exchange at sea, the safety aspects of which are described in an appendix to the Resolution.

IMO currently recognises two methods for ballast water exchange at sea; the flow-through and the sequential. A key aspect of the ballast exchange philosophy is the assumption that mid-ocean aquatic lifeforms will not survive in coastal waters (and vice versa). It follows from this assumption that any ballast water exchange must take place in open deep waters.

Existing legislation in Australia, Canada, Chile, Israel, New Zealand and the USA requires ships to exchange or treat ballast at sea prior to entering port, coastal or state waters. This process is expected to be carried out according to the ship's BWMP.

At present, whilst IMO works on a definition of the approval mechanism of the BWMP, the BWMP is considered to be the responsibility of the Administration with whom the ship is registered (Flag State), whereas the criteria for acceptability of the ballast water management methods employed rests with the Administration within whose territorial jurisdiction the ship is intended to operate (Port or Coastal State).

The Administrations are introducing regulations for ballast exchange at sea which aim to provide a solution to a socio-economic problem. However, since the majority of the world's fleet is not designed to function safely in the manner expected by the Administrations, these regulations will result in techno-economic problems, which need to be addressed and resolved.

LR, prompted by the fact that issues pertinent to the sequential method have not yet been fully appreciated by the industry, commenced a two-part study using 26 existing ships of various types, configurations and sizes. The objectives of the study are as follows:

- The objective of the first part of the study is to investigate the effects of the sequential method on the ship's structure and the assessment criteria in respect of classification, statutory and operational aspects.

- The objective of the second part of the study is the development of a safe operational envelope, on the basis of sea-keeping analysis, to control the dynamic effects for the ballast condition under consideration.

Overall, the study serves as a reference guide for Administrations who intend to develop ballast water management policies.

4 General Criteria

Criteria governing the sequential method could be related to classification, statutory and operational aspects. Classification aspects infer global and local strength. Statutory aspects infer stability and visibility. Operational aspects infer trim.

Classification aspects:

- Longitudinal strength (i.e. permissible still water bending moments, shear forces and cargo torque)
- Dynamic loads (i.e. fatigue, ballast inertia and sloshing in tanks)

Statutory aspects:

- Intact stability (i.e. metacentric height, etc.)
- Bridge visibility (i.e. sea surface limit from the conning position, etc.)

Operational aspects:

- Minimum draught forward (i.e. risk of bottom forward slamming)
- Propeller emergence (i.e. risk of temporary reduction of manoeuvrability and slamming aft)

Operational aspects are inter-linked with classification and statutory aspects.

5 The Study

In the course of the study, twenty six ships of various types, configurations and sizes were considered. These included three single skin tankers, one double skin tanker, four double hull tankers, four single side skin bulk carriers, five container ships, two liquefied natural gas carriers, two self-discharging bulk carriers, three oil-bulk-ore carriers and two general cargo ships (Table 1). Both light and heavy ballast conditions were investigated in the departure and arrival conditions, using the sequential method for all ballast tanks. For the purposes of the study the following criteria have been considered:

- Assigned permissible still water bending moments and still water shear forces. The calculations were carried out for full and empty tanks assuming that the hull girder is in good condition.
- As an indication of the ship's intact stability, the metacentric height corrected for free surfaces was checked against the ship's minimum metacentric height at 20% and 50% fill levels, whilst port and starboard ballast tanks were assumed to be exchanged simultaneously in order to prevent heeling.
- As an indication of the ship's bridge visibility, the view of the sea surface forward of the bow from the conning position was checked to be not more than two ship lengths or 500m whichever is the less. It is recognised that not all existing ships comply with *SOLAS 1974, Chapter V, Safety of navigation, Regulation 22, Navigation bridge visibility*. In such cases, existing ships are expected to comply in respect of forward view and blind sectors in so far as is practicable without structural alteration being required.
- Minimum draught forward as indicated in the ship's plans and/or loading manual. Where not mentioned, this was taken as 0,045L.
- Propeller immersion (top dead centre of propeller in still water).

Typical Datasheets indicating results for each step during the sequential exchange are shown in Tables 2 and 3.

Dynamic loads were investigated separately for selected cases. The derived maximum lifetime pressures were compared with the pressures derived from *ShipRight Structural Design Assessment Ultimate Strength Program (10604)*, with and without allowable diminutions and excluding hull girder effects.

Table 1
Ships considered in the LR Study

Ship type	Description	L x B x D [m]	Year	Total ballast capacity [m³]	Dead weight [tonnes]
Oil Tanker					
	Single skin with two long. bulkheads	217 x 32.2 x 19.6	1990	40397	62485
	Single skin with two long. bulkheads	234 x 42.68 x 21.5	1990	59168	106679
	Single skin with two long. bulkheads	313 x 56.6 x 28.6	1995	122308	258076
	Double side	177 x 27.43 x 17	1988	19636	39988
	Double hull with a centreline bulkhead	173 x 32.2 x 17.8	1996	21865	47252
	Double hull	264 x 43.9 x 24.4	1992	73097	154970
	Double hull with two long. bulkheads	327 x 56.4 x 30.4	1993	119878	298900
	Double hull with two long. bulkheads	320 x 58 x 31	1998	132631	311189
Bulk Carrier					
	Handysize, single side skin	177 x 30.4 x 16.5	1996	26575	45654
	Panamax, single side skin	216 x 32.2 x 19.1	1994	35151	73236
	Capesize, single side skin	256 x 40.5 x 21.2	1996	55171	122301
	Capesize, single side skin	270 x 43.0 x 24.1	1994	85592	151301
Container Ship					
	1725 TEU	174 x 27.4 x 15.8	1998	9677	24554
	2668 TEU	225.5 x 32.2 x 18.8	1993	19199	47120
	3429 TEU	241.5 x 32.2 x 19.2	1996	13830	46350
	3842 TEU	246 x 32.25 x 19.3	1998	11991	48224
	4477 TEU	263 x 37.1 x 21.7	1995	19933	61428
Liquefied Natural Gas Carrier					
	Membrane type	260 x 43.3 x 25.4	1997	46538	62500
	Moss type	276 x 46 x 25.5	1990	53751	78988
Self-Discharging Bulk Carrier					
	Double hull	170 x 27.6 x 16.1	1988	18576	36634
	Double hull	194 x 32 x 19	1993	33473	50587
Oil-Bulk-Ore Carrier					
	Double hull	200 x 32.2 x 17.35	1984	32851	54500
	Double hull	234 x 38 x 22.3	1991	61311	95000
	Double hull	275 x 45 x 25.9	1992	61436	169416
General Cargo					
	Multipurpose cargo ship	162 x 25.6 x 14.2	1999	6300	22948
	General cargo/container carrier	185 x 32.2 x 17	1984	11865	41600

Table 2
Capesize Bulk Carrier – BC3 – Light Ballast Departure

STEP	MODE	PS SB	BWT APT	BWT NO 5	BWT NO 4	BWT NO 3	HOLD NO 6	BWT NO 2	BWT NO 1	BWT FPT	T_{AFT} [m]	T_{FWD} [m]	P_{IMM} [m]	SWBM -	SWSF -	Bridge Visibility -
0											8.64	5.24	0.24	OK	OK	OK
1	SEQUENTIAL										6.31	6.04	-2.09	OK	OK	OK
2	SEQUENTIAL										6.55	5.23	-1.85	NOT OK	OK	OK
3	SEQUENTIAL										8.10	3.83	-0.30	NOT OK	OK	NOT OK
4	SEQUENTIAL										9.64	2.49	1.24	OK	OK	NOT OK
5	SEQUENTIAL										9.54	3.65	1.14	OK	OK	NOT OK
6	SEQUENTIAL										8.89	4.86	0.49	OK	OK	OK
0											8.64	5.24	0.24	OK	OK	OK
Capacities [m³]			969.4	5773.4	8620.6	8867.8	15401.3	8715.8	3725.6	3053.6						
Fill [%]			0	100	100	100	0	100	100	26						

Ballast water before exchange Empty Exchanged ballast water

Table 3
Double Hull Oil Tanker – OT6 – Heavy Ballast Departure

STEP	MODE	TST BTM	BWT APT	BWT NO 5	BWT NO 4	BWT NO 3	HOLD 5	BWT NO 2	BWT NO 1	BWT FPT	T_{AFT} [m]	T_{FWD} [m]	P_{IMM} [m]	SWBM -	SWSF -	Bridge Visibility -
0											10.42	10.14	2.05	OK	OK	OK
1	SEQUENTIAL										10.16	10.28	1.79	OK	OK	OK
2	SEQUENTIAL										8.31	10.91	-0.06	OK	OK	OK
3	SEQUENTIAL										7.72	10.52	-0.65	OK	OK	OK
4	SEQUENTIAL										9.25	9.17	0.88	OK	OK	OK
5	SEQUENTIAL										10.78	7.83	2.41	OK	OK	OK
6	SEQUENTIAL										12.22	6.56	3.85	NOT OK	OK	NOT OK
7	SEQUENTIAL										11.81	7.90	3.44	NOT OK	OK	NOT OK
8	SEQUENTIAL										9.14	7.74	0.77	OK	OK	OK
0											10.42	10.14	2.05	OK	OK	OK
Capacities [m³]			1735.3	5576.8	10306.0	10557.4	18581.3	10557.4	10466.0	5315.9						
Fill [%]			28	100	100	100	100	100	100	100						

Ballast water before exchange Empty Exchanged ballast water

6 Findings

Regarding use of the sequential method only, the following findings can be deduced.

6.1 Longitudinal Strength

- All single skin tankers and oil-bulk-ore carriers indicated insufficient longitudinal strength.
- Some double hull tankers indicated insufficient longitudinal strength.
- Single side skin bulk carriers indicated that longitudinal strength could be sufficient only in the light ballast condition.
- One of the two self-discharging bulk carriers indicated insufficient vertical bending strength.
- Container ships indicated sufficient longitudinal strength. However, it should be noted that such ships rarely operate in *ballast only* conditions, since containers are normally loaded and off-loaded at each port. Ballast is allocated during the course of the voyage to accommodate changes in the distribution of cargo and consumables.
- Liquefied natural gas carriers indicated sufficient longitudinal strength.
- General cargo ships indicated sufficient longitudinal strength only in the ballast arrival condition.

6.2 Metacentric Height

- All cases indicated sufficient metacentric height corrected for free surfaces.

6.3 Sea View (fig. 2)

- In the light ballast condition, most cases indicated insufficient view of the sea surface forward of the bow from the conning position.
- Two tankers, one self-discharging bulk carrier and the two general cargo ships indicated sufficient view of the sea surface forward of the bow from the conning position.

6.4 Minimum Draught Forward

- Most cases resulted in draught forward less than the minimum draught forward value, which could result in bottom forward slamming.

6.5 Propeller Immersion

- Apart from container ships, most cases resulted in propeller emergence, which could result in temporary reduction of manoeuvrability and slamming aft.

6.6 Dynamic Loads – Fatigue

Emptying and refilling of a ballast tank imposes an additional load cycle. There is concern that the fatigue performance of the end connections of longitudinals could be reduced due to the increased number of loading cycles. For critical locations where the mean stress is shifted to a greater tensile stress, the fatigue life will be reduced. This matter needs to be investigated in future studies.

6.7 Dynamic Loads – Ballast Inertia

For bulk carriers, the combination of full ballast holds and empty topside and hopper tanks may induce dynamic loads, which could exceed the capability of the sloped bulkhead structures (fig. 3).

6.8 Dynamic Loads – Sloshing

Regarding sloshing in partially filled topside and hopper ballast tanks and ballast holds of single skin bulk carriers, the following general findings can be deduced:

- Partial filling of ballast holds should be avoided (fig. 4).
- Partial filling of topside tanks should be avoided in light ballast conditions (fig. 5).
- Partially filled hopper tanks should not give rise to sloshing concerns.

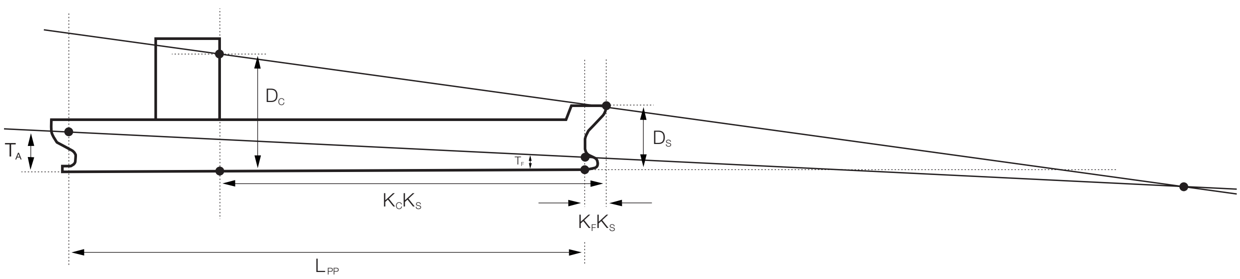


Figure 2 – View of the sea surface forward of the bow from the conning position

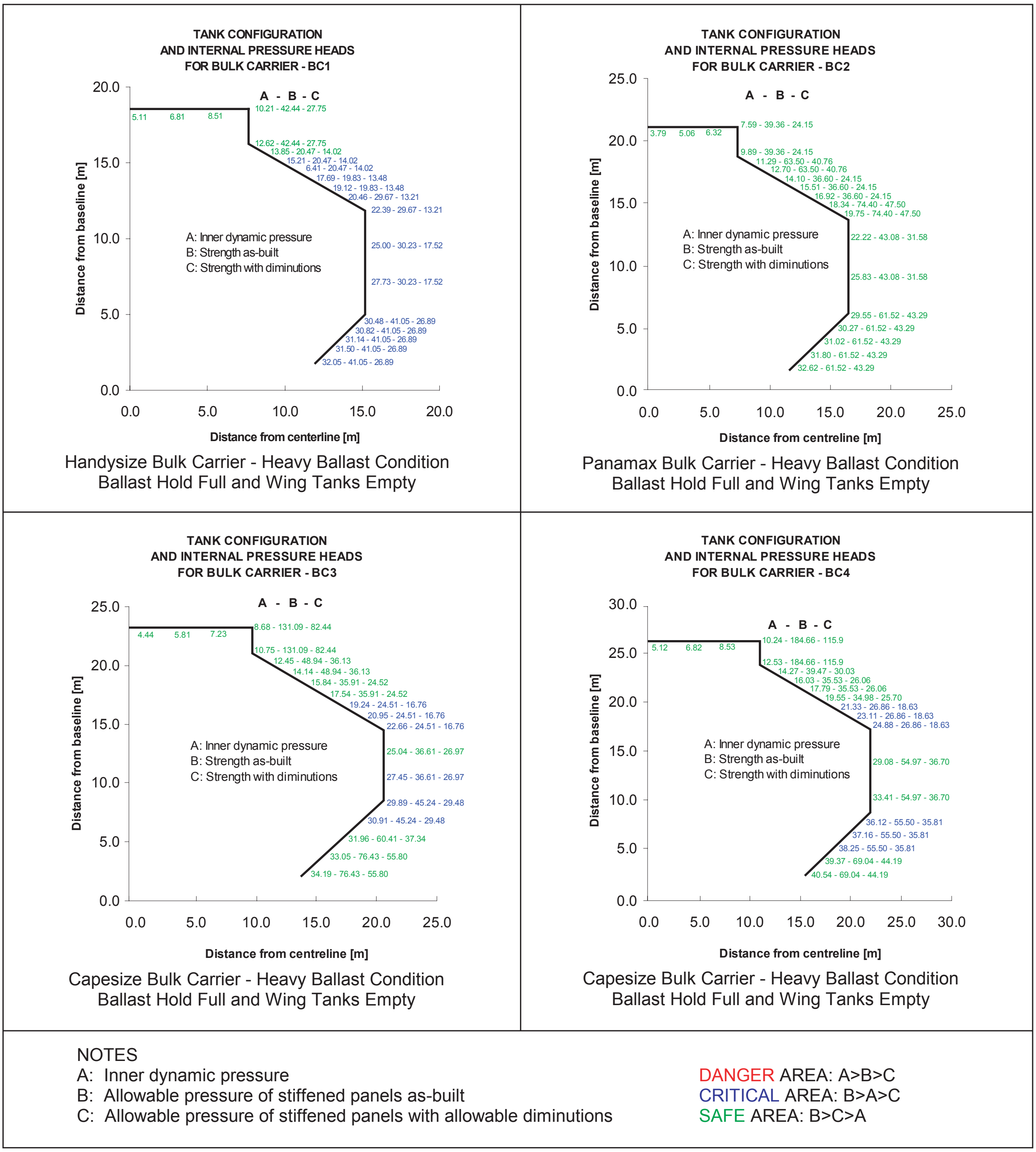
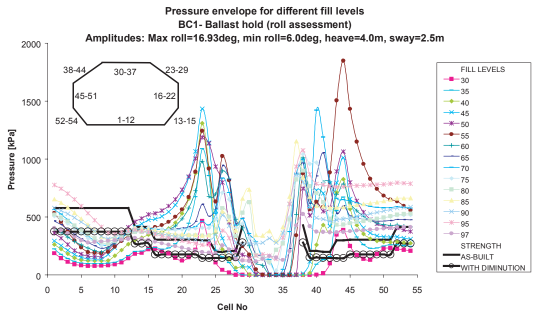
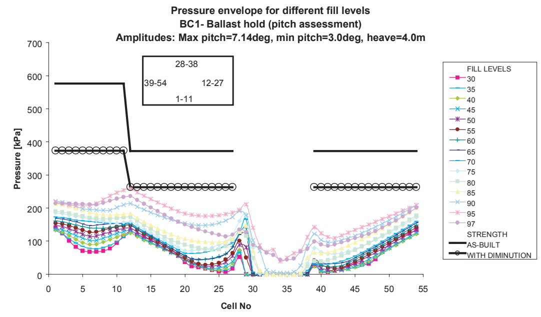


Figure 3 – Bulk carrier configuration and ballast inertia pressures

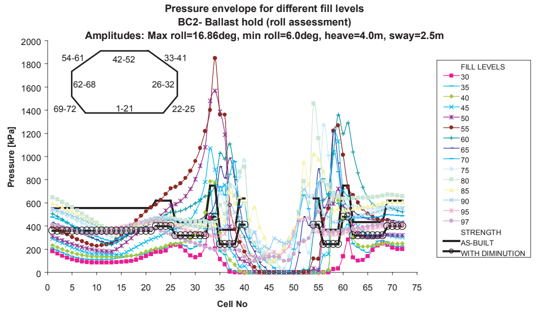
ROLL ASSESSMENT	PITCH ASSESSMENT



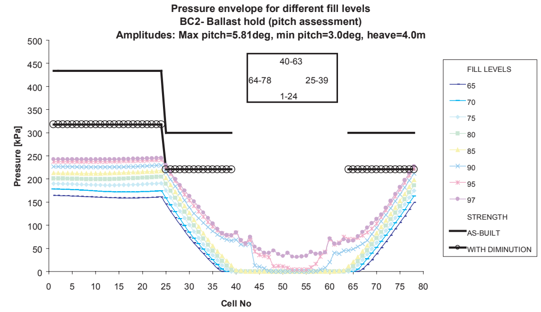
Handysize Bulk Carrier – Heavy Ballast Condition



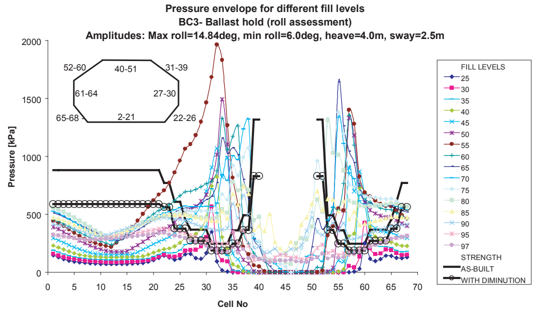
Handysize Bulk Carrier – Heavy Ballast Condition



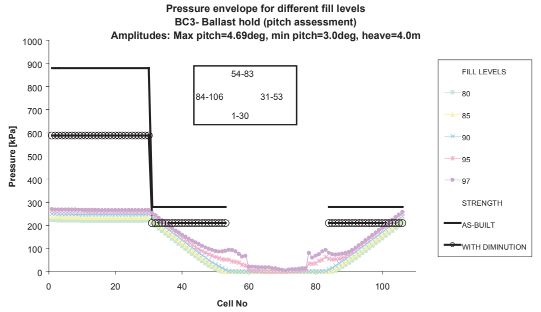
Panamax Bulk Carrier - Heavy Ballast Condition



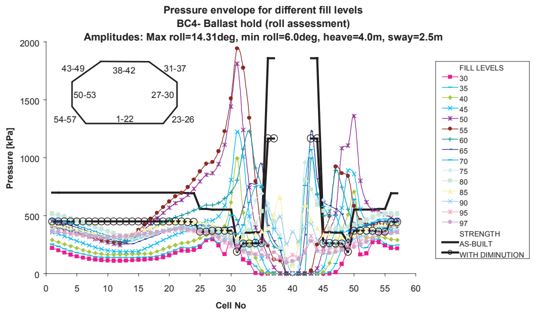
Panamax Bulk Carrier - Heavy Ballast Condition



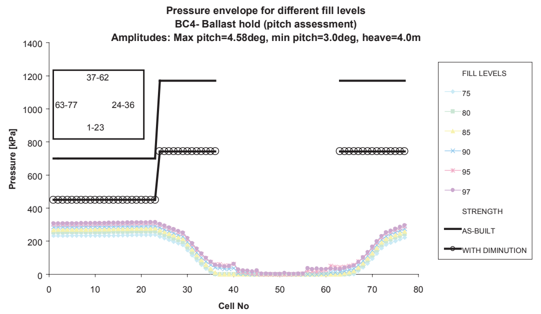
Capesize Bulk Carrier – Heavy Ballast Condition



Capesize Bulk Carrier – Heavy Ballast Condition



Capesize Bulk Carrier - Heavy Ballast Condition



Capesize Bulk Carrier - Heavy Ballast Condition

Figure 4 – Sloshing assessment of ballast holds

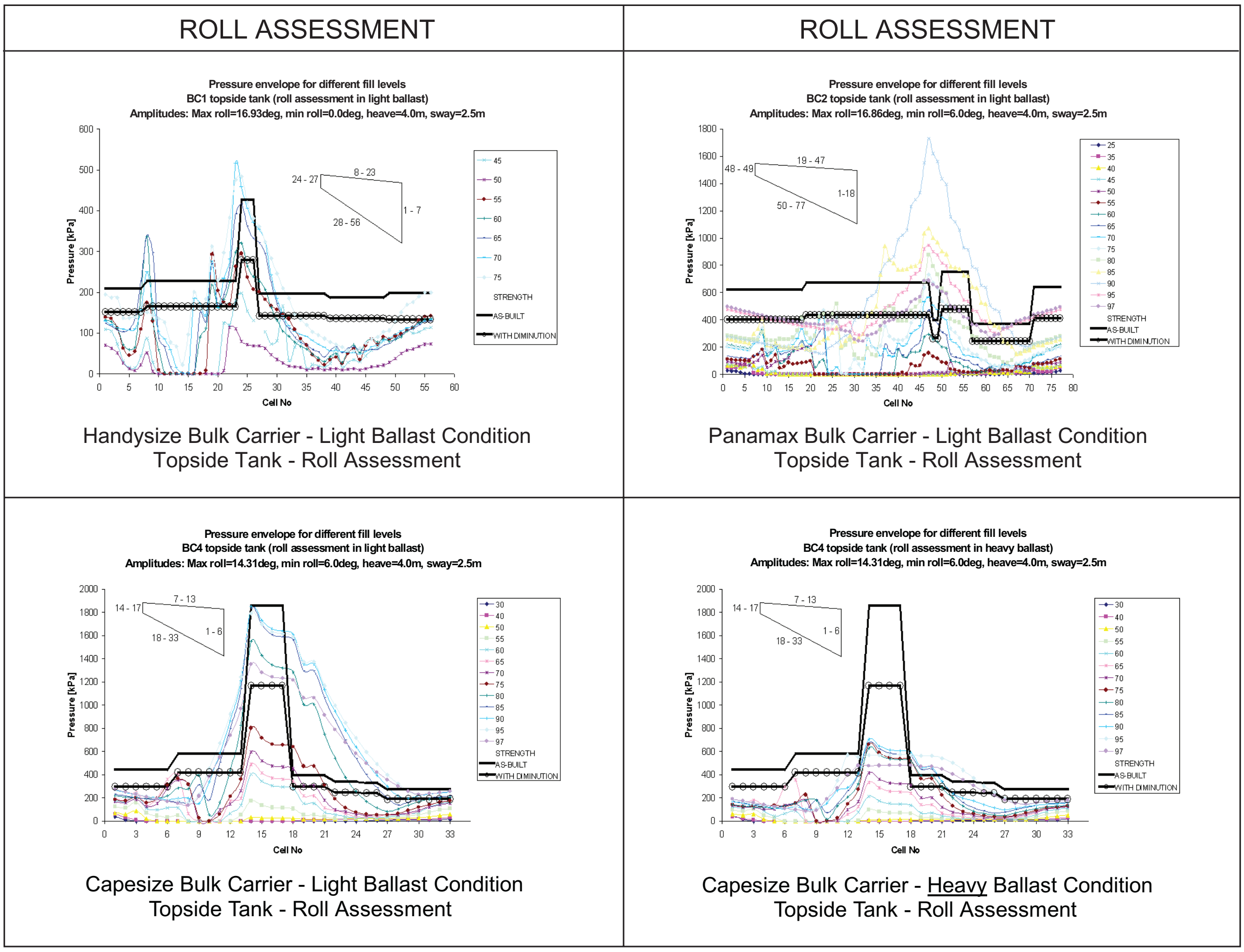


Figure 5 – Sloshing assessment of topside tanks

Regarding sloshing in partially filled ballast tanks of single skin oil tankers, the following general findings can be deduced:

- Partial filling of ballast tanks of single skin oil tankers should be avoided, unless the tanks are designed for unrestricted filling levels for the ballast condition under consideration.
- Wing ballast tanks of single skin oil tankers fitted with transverse ring web structures can be excluded from the sloshing investigation.

In addition, the following general comments are provided:

- Unless tanks are approved for unrestricted filling levels, a sloshing investigation may be required.
- Although LR's Level 1 sloshing analysis may indicate that sloshing is likely to occur, further analysis would be needed to assess the structural capability, which could be sufficient to withstand the maximum sloshing loads.
- Where tanks are tapered in plan view, such as the foremost and aftermost peak tanks, limited model experiments have indicated that in pitching, the dynamic pressure on the bulkhead at the narrow end can be magnified when compared with a tank of uniform section. Peak tanks fitted with a centreline wash bulkhead or a centreline ring structure or horizontal ring structures can be excluded from the sloshing investigation.
- Wash bulkheads, which represent more than 85% of the tank's cross sectional area, can be taken as being effective sloshing barriers.
- Where two or three frames or transverse members are fitted instead of a wash bulkhead, the pressure on the watertight bulkhead has been observed to decrease to about 80% of the dynamic pressure obtained without frames or transverse members. The dynamic pressure is not found to decrease further with increasing numbers of frames or transverse members.
- Sloshing need not be investigated for double bottom tanks and double side tanks for all ships and hopper tanks of bulk carriers.
- Sloshing need not be investigated for topside tanks of bulk carriers in the heavy ballast condition.

7 Options to Mitigate Risks

Administrations who accept the sequential method have not yet defined clear assessment methodologies and criteria.

Where the sequential method is utilised and the criteria are not achievable for all ballast spaces, consideration could be given to the adoption of one or a combination of the following options, **provided they are acceptable to the Administration(s) and the Operator**:

- Diagonal sequential method
- Flow-through method
- Operational envelope*
- Modifications
- Isolation
- Treatment

*Reference is made to the recent IMO document *MEPC 44/4*, which is the report of the IMO working group on ballast water. Of particular interest are regulations 13 and 15. Regulation 13 deals with a requirement for ships to have onboard a BWMP approved by the Administration. Regulation 15 deals with requirements for the structure and equipment of ships. Paragraph 15.1(c)iii refers to "favourable sea and swell conditions". Paragraph 15.2 refers to procedures for ballast water management options which account for "admissible weather conditions", "minimum/maximum forward and aft draughts so as to prevent slamming forward, maintain manoeuvrability and maintain bridge visibility", "wave induced hull vibration", etc. With the exception of "wave induced hull vibration", which does not seem to have a clear assessment methodology and criterion, the other references indirectly refer to the development of an operational envelope to control dynamic effects. It is noted that the development of ship specific operational envelopes would require considerable manpower, even if appropriate procedures and software applications were available.

The question of performance standards has been raised at IMO by Greece who pointed out that it is necessary to develop an approval mechanism for alternative management techniques. According to Greece, the effectiveness of new techniques must be able to be compared with ballast water exchange and a systematic approach must be established. It is encouraging to see that this aspect appears in MEPC 44/4 paragraph 2.10.2.

7.1 Diagonal Sequential Method

With this method, simultaneous emptying and refilling of closely matched diagonal tanks is carried out.

The feasibility of the diagonal sequential method was investigated for six ballast cases that did not comply with the criteria of the study.

It can be deduced that the diagonal sequential method could be an effective method for reducing the still water bending moment and shear force to within permissible levels. Simultaneous emptying and refilling of closely matched diagonal tanks will control heeling. The diagonal sequential method could induce hull girder torque which could be minimised provided the selected tanks are relatively close and the ship's heading is as close as practicable to head seas.

7.2 Flow-through Method

Although there are risks and disadvantages with the flow-through method (see page 4), this method could be considered for tanks that fail to meet the criteria for sequential exchange, provided the scantlings of the tank boundary structure are designed for a tank head equivalent to the full distance to the top of the overflow.

Unless operational limits are specified, it can be deduced that the flow-through method could, in general, be needed for:

- the ballast holds of bulk carriers in the heavy ballast condition
- the topside tanks of bulk carriers in the light ballast condition
- the ballast tanks of single skin tankers
- the fore and aft peak tanks of bulk carriers and tankers

Where peak tanks are partially filled, the flow-through method should be avoided unless any inadvertent exceedance of the design partial filling levels will not result in hull girder bending moments and shear forces exceeding the permissible values.

Administrations who accept the flow-through method have not yet defined clear assessment criteria. Some Administrations require a minimum replacement of 95% of the original volume, yet fail to recognise that this figure may only be achieved or approached provided there is adequate flow in all areas of the tank, i.e. no areas of stagnation. Therefore, if the figure of 95% needs to be satisfied, a distributing grid of pipes would be required to ensure reasonably equal flows within the tank. It is estimated that retrofitting pipework to this extent would be a considerable expense, especially for existing ships. In this respect and in the light of recent legislation of some American Coastal States (see page 16), investing in this method is likely to be seen by Operators, who need to trade in these waters, as a solution with limited potential. The retrofitting costs of a distributing grid of pipework could balance or outweigh the installation costs of a treatment system when available in future (see page 18).

7.3 Operational Envelope

It is considered that the present practice, whereby sequential ballast exchange conditions are approved on the basis of 'calm weather' or 'calm sea', is not practical for the majority of Operators. It is noted that the World Meteorological Organisation (WMO) defines a 'calm sea' as one where the significant wave height range is 0 – 0.1m. 'Calm seas' are rarely found in open deep waters and this leaves little margin for operations to be carried out effectively and safely.

It is recognised that the *IMO MEPC 44/4, Report of the Working Group on Ballast Water convened during MEPC 43* makes reference to the ship's assigned permissible still water bending moments and shear forces. However, in order to satisfy these criteria many new sequences involving partially filled tanks may need to be introduced in the ballast exchange plan. This would imply that the ship's Master would have to ensure that the various filling levels are closely monitored and never exceeded. Such a ballast exchange plan could put a lot of strain on the ship's staff and, therefore, its practicality and safety implications could be questionable.

Solutions to these problems can be provided by managing the risks. This can be done by allowing the long-term criteria for longitudinal strength, sloshing, slamming and ballast inertia to be exceeded in the short term, provided the ship is operated within well defined and acceptable operational limits. Where the strength criteria are not satisfied, limits can be defined in terms of response amplitude operators. Structural degradation, if any, can also be reflected in the derivation of the operational limits.

Taking into account the ship's actual hull form and weight distribution, direct calculations can be carried out for the derivation of response to regular waves by strip theory and short-term response to irregular waves using the sea spectrum concept. Subsequently, a solution can be developed in the format of an operational limit card. An operational limit card is defined in terms of permissible significant wave height and/or observed wave height, speed, heading, duration of operation and probability of exceedance of the specified limit. The combination of the selected limit cards produces the ship's operational envelope. The concept of the operational envelope is shown in fig. 6 in the form of a polar plot with 30 degree intervals, showing the permissible observed wave height in metres, for various speeds, in short-crested seas and in long-crested seas.

It is recognised that this approach could be laborious for each step of the sequential exchange. In this respect, LR has developed ***LIMITS***, an in-house software package for seakeeping analysis and for the efficient derivation of operational envelopes. The operational envelopes could be ship specific or ship generic.

The operational envelope is a risk management approach solution and is based on self-regulation. Where operational limits have been defined for specific ballast exchange conditions, these would require to be adhered to during operation.

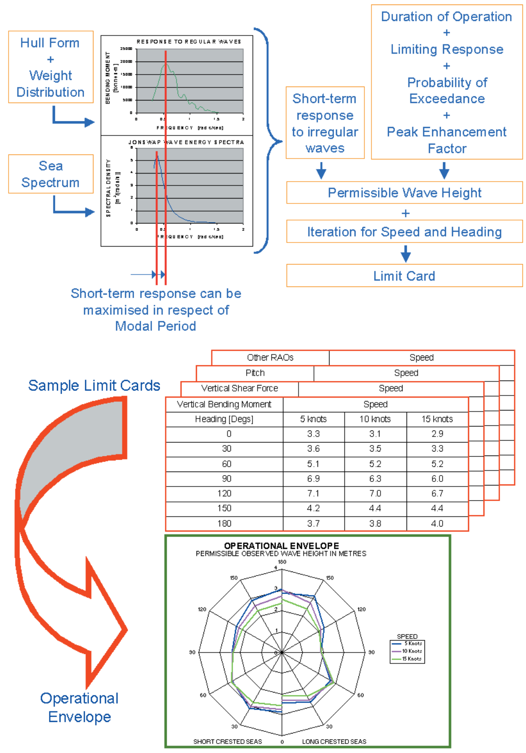


Figure 6 – The concept of operational envelope

7.4 Modifications

It is recognised that modifications may be needed in respect of the structure and/or engineering systems.

For flow-through systems, it is recommended that the inlet and outlet piping connections are located as remote as practicable from each other.

For flow-through systems, the double bottom and peak tanks may need additional pipework to improve the mixing conditions.

For flow-through systems, the total sectional area of the ballast water discharge pipes on the upper deck should not be less than two times that of the sectional area of the filling/suction pipe. The size of one of the two ballast water discharge pipes on the opposite side of the filling/suction pipe should be bigger than the other ballast water discharge pipe. For instance, for a 250mmØ filling/suction pipe, 300mmØ and 200mmØ discharge pipes could be fitted.

Air pipes on ballast tanks are intended to allow air to escape, or enter, a tank during ballast operations and are usually of flat disc type or ball float (see fig. 7). They are not meant to be, or capable of, handling large scale discharge of water ballast which can result from continuous ballast pumping as experienced in flow-through systems. Air vents with automatic closing devices are recommended.

It is noted that where topside and hopper side tanks are not interconnected, the scantlings of the hopper and double bottom tanks are normally derived using the head to the top of the tank or half the distance to the top of the overflow, whichever is the greater. Traditionally ballast tanks are filled until ballast water overflows. Subsequently, the water pressure at the tank bottom drops immediately due to entrapped air, which reduces the water level in an overflow pipe of a small diameter. However, the flow-through method will result in a constant high pressure during the long periods required to complete the operation. Therefore, for flow-through systems where topside and hopper side tanks are not interconnected, the scantlings of the tank boundary structure should be verified using a tank head equivalent to the full distance to the top of overflow.

Whilst damage to a ship due to over-pressurisation of tanks appears an obvious possibility, it is sometimes overlooked that for sequential systems under-pressure could, in some cases, result in more severe damage. Under-pressure is created by a large drop in pressure, due to the rapid change in the contents of the tank. For instance, it is common on bulk carriers to discharge by gravity that part of the ballast above the load waterline through an overboard valve, which gives rise to a potential high vacuum due to the rapid rate of discharge. Unfortunately, air pipes alone do not have the capability of handling such large changes in pressure as those which occur due to discharge by gravity and, unless hold ventilators are open prior to discharge, then serious damage could occur.

For sequential systems, the increased frequency of partial ballast water discharges by gravity is likely to result in more damage incidents such as that shown in fig. 8.

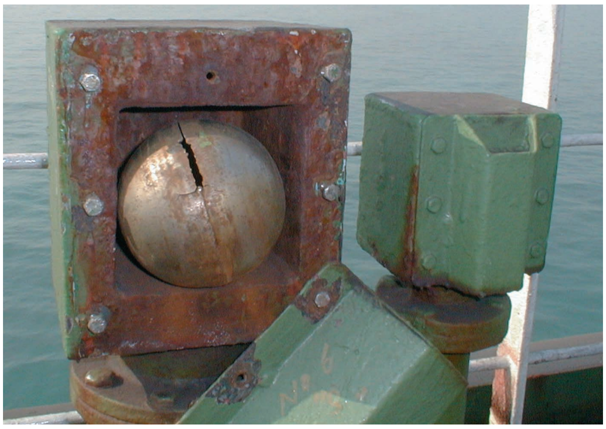


Figure 7 – Air vent head with broken ball float

It is anticipated that for sequential systems this kind of operation will be performed in open seas, probably far away from a safe haven, which makes the effect even more undesirable.

Operators need to take precautions to avoid being in this position.

Ballast holds are normally provided with adequate ventilators, which should ensure that the hold would not be subjected to excessive pressure or vacuum. For sequential systems, it is recommended that the bilge suctions are blanked, the blanks removed from the water ballast connections and the ventilator covers are kept open whenever the floodable hold is being used for the carriage of ballast, and during ballasting and deballasting. Similarly, before the hold reverts to the carriage of dry cargo the above blanking and unblanking process must be reversed.

Figure 8 – Vacuum damage in way of a ballast hold

For sequential systems, it is recommended that ballast holds and large ballast tanks are equipped with pressure/vacuum valves. These valves need to be maintained in good working order, as a chocked pressure/vacuum valve could result in hatch cover damage.

For sequential systems, where operational limits are specified, at least two independent pumps should be fitted. These should be arranged such that, if one pump fails, then the stand-by pump is immediately available for operation. It has been reported that most ships are equipped with two exclusive service pumps and, therefore, this recommendation may not have design ramifications for most ships in service.

Plans and particulars of any proposed modifications need to be submitted for approval before the work commences and the work is to be carried out in accordance with the approved plans to the Surveyors' satisfaction.

7.5 Isolation

It is considered that, for large passenger ships, the sequential method should not pose problems, since these ships often have limited ballast capacity that is used to compensate for usage of consumables. These ships could retain the ballast on-board and re-distribute it internally or exchange it during or at the end of the return voyage if navigating outside the Exclusive Economic Zone (EEZ).

It is noted that tankers utilising the concept of Hydrostatic Balance Loading have restrictions on changing their draft and trim. In certain cargo loading conditions, where ballast is taken in, the ballast would have to remain on-board and be exchanged during the ballast leg of the voyage or, if feasible, discharged to reception facilities.

The option of reception facilities is seen as a very limited solution since not many ports are likely to provide these. The Flotta terminal at Scapa Flow in the Orkney Islands, which can take ballast water from tankers, is a rare example although it has been reported that a design for an environmental treatment barge is under consideration in Norway.

7.6 Treatment

Any treatment system acceptable to the Administration(s) can be selected. However, what constitutes an acceptable method has not yet been clearly defined by the Administrations. Therefore, without specific internationally agreed criteria, what is acceptable to one Administration may not be acceptable to another now or in future.

Invasion of unwanted matter dates back to 1903 when a large mass of Asian phytoplankton was found in the North Sea. Recently reported invasions are given in Table 4 and typical critters are shown in fig. 9.

Defining the *enemy* is not the only problem that Administrations are facing. Treatment systems, before being accepted as standard ship equipment, need to prove their effectiveness for specific *enemies*, i.e. to ensure that the *enemies* will not pose a threat after treatment.

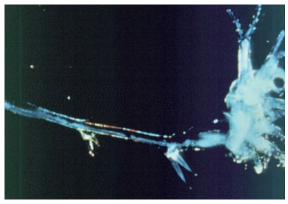
It would appear that the United States Coast Guard (USCG) perceives treatment methods as being capable of achieving 100% exchange. It has been reported that in the medium to long term the USCG consider open ocean ballast exchange as only an interim measure; until such time as a suitable treatment technology is identified.

A Bill has been introduced in the Michigan legislature (Senate Bill No 955) to require that ships bringing ballast water into Michigan from outside the state must sterilize the ballast water and any sediments contained therein. Ships may not discharge unsterilized ballast water into Michigan waters. An exception is made for operations authorized by a state permit. The Michigan Department of Environmental Quality would be required to establish a ballast water inspection program and would be allowed to assess application and inspection fees. It has been reported that the ninth version of Bill 955 is underway which, realising that sterilisation is obviously not possible for all water and sediment in a tank, has opted for exchange, management practices and best available technology.

The California State Assembly Bill 703, as proposed by Assembly Member Lempert, requires zero discharge of live organisms. AB703 requires the sampling and monitoring of ballast water from a minimum of 10% of all vessels discharging ballast water in Californian waters. It also requires the following:

April 2000 to December 31, 2002
AB703 prohibits discharge of ballast water initially loaded from coastal waters outside the Pacific Coast Region into

Green crab



Spiny water flea

Ruffe

Rainbow jellyfish

Zebra mussels basal threads

Tubenose Goby

Figure 9 – Typical critters

Table 4
Recently reported invasions

Critter	Origin	Introduced to	First sighted
Zebra Mussel	Eurasia	Great Lakes	1980s
Ruffe	Eurasia	Great Lakes	1980s
Tropical Green Algae	Tropical Seas	Mediterranean Sea	1980s
Comb Jelly	US East Coast	Black Sea	1970s
Giant Fan Worm	Mediterranean Sea	Southern Australia Ports	1980s
Northern Pacific Seastar	Japan & Alaska	Tasmania, Australia	1986
Northern Pacific Kelp	Northern Pacific	Tasmania & Port Bay, Australia	1987
European Shore Crab	Europe	San Francisco Bay	Early 1990s
Round Goby	Caspian & Black Sea	Great Lakes	1995
Mitten Crab	China	San Francisco Bay	1992

Californian Waters or waters that impact upon Californian Waters, without a Permit*.

*The Permit, which is obtained from the State Board, requires either:

(a) Carry out an adequate exchange of ballast water in open ocean waters. For the purposes of this section an adequate exchange is one that replaces at least 95% of the original volume of water in the tank with open ocean water.

Or

(b) Use an alternative environmentally sound method of ballast water treatment that has been approved by the Board and that it is at least as effective in removing or killing the exotic ballast water organisms in the initially loaded ballast water as the exchange described above, if that method is feasible.

From January 2003
AB703 prohibits discharge of ballast water containing live exotic organisms, into Californian waters by any vessel except by Special Permit**.

**The Special Permit is issued if:

Between January 1, 2003 and December 31, 2004
Vessels conform to (a) or (b) for the normal Permit (see above) and both the following:

(a) The applicant has commenced the construction or installation of facilities or mechanisms for treating or managing ballast water that will result, in the judgement of the Board, in the elimination of discharges containing live exotic ballast water organisms from all vessels to which the permit applies.

And

(b) The applicant has provided the Board with a schedule for completion and implementation of those facilities or mechanisms on or before December 31, 2004.

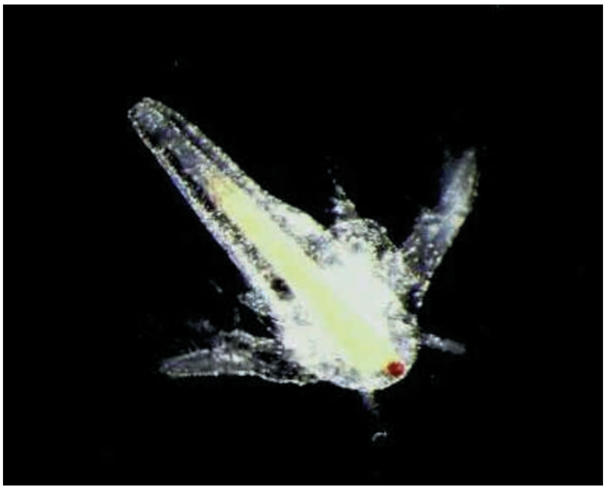
From January 2005
The applicant is using facilities or mechanisms for treating or managing ballast water that will result, in the judgement of the Board, in the elimination of discharges containing live exotic ballast water organisms from all vessels to which the permit applies.

Although AB703 (Lempert) is supposed to be effective from April 2000, the California State has not yet clarified whether flow-through systems without a distributing grid of pipes (see page 13) are acceptable.

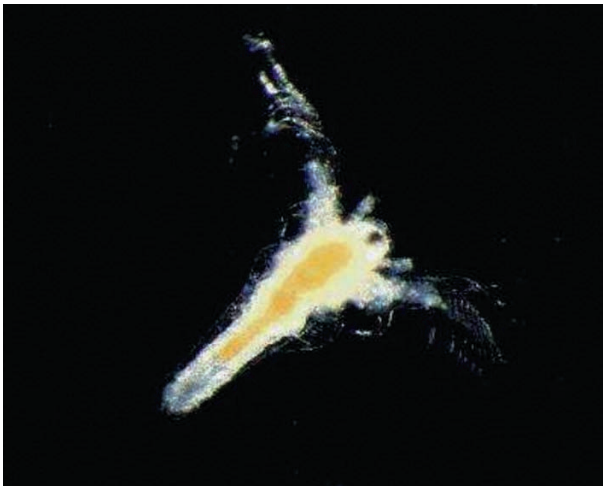
In 1991 there was a case of a large colony of mussels in Mobil Bay being contaminated by a ballast discharge containing Cholera. As a result of this type of incident, the issue of ballast water treatment has also had to focus on the threat posed by viruses as well as organisms. Physical separation technology should play a significant role in any ballast water treatment system but, according to those who work in the microscopic realm, no single technology can remove all life forms from ballast water. Ultraviolet radiation has played a key role in the field of microscopic disinfection for some time within the marine field and, therefore, it has been identified as having great potential with respect to ballast water treatment.

Ultraviolet is the part of the electromagnetic spectrum with waves shorter than light but longer than X-rays. Ultraviolet light consists of radiation in the ultraviolet and it is known to destroy the organic cells and proteins that form constituent components of a multitude of microscopic life forms. An example of such destruction is shown in fig. 10. Note the opaque appearance of the body in fig. 10(b) compared to that in fig. 10(a), signifying denaturing proteins as well as signs of a destroyed exoskeleton.

Below the 50µm level, other key organisms such as the dinoflagellate Prorocentrum Minimum (fig. 11) would have



(a) Before UV illumination



(b) After UV illumination

Figure 10 – Artemia Naupilus larva exposed to UV

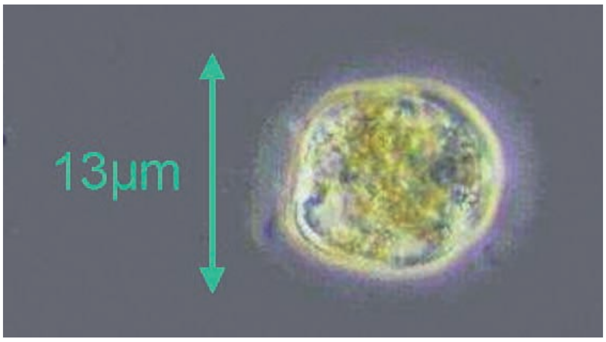


Figure 11 – Prorocentrum Minimum

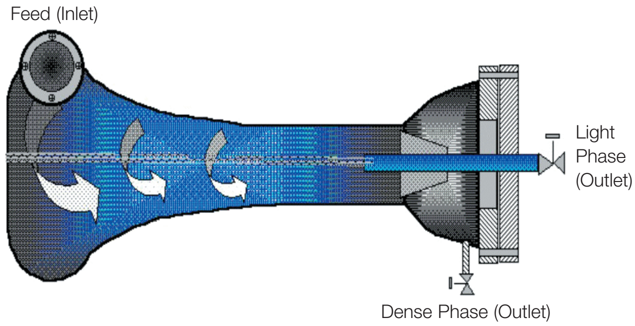


Figure 12 – An illustration of a cyclonic separator with its principle features

a much lower chance of survival after a short exposure (few seconds) to ultraviolet radiation.

Ultraviolet radiation represents "tried and tested" technology on ships and could be, generally, a relatively comfortable choice for many operators.

Above the 50µm level, it has been reported that there are self-cleaning filters which can accommodate flow rates of approx. 300m³/hour, incorporating self-cleaning devices such as brushes, for the removal of accumulated solids from the screen surfaces. During the screening cycle, back flushing could also be incorporated in order to facilitate the removal of solids. The space envelope required to accommodate such a filter would be in the region of 1m x 1.5m x 0.8m with mass of approx. 0.75 tonnes. However, scientists have warned that it may be possible under certain conditions that the back flushing of an intake filter could result in a population density of certain organisms which is high enough to constitute the critical mass required to cause a "bloom". This would have a negative ecological impact by actually causing an event which ballast treatment is designed to prevent.

Despite the degree of integrity that filtration can introduce to a system, the initial costs as well as maintenance, space and weight constraints could be seen by some Operators as a significant degree of burden.

A different physical separation device, that has great potential for ballast water treatment, is the cyclonic separator. A cyclonic separator has no moving parts and consists of a hollow, central core with a helical geometry that tapers at one end (fig. 12).

With respect to ballast operations, the flow of water enters via the widest section of the core and is subsequently subjected to increasing centrifugal force as it is accelerated

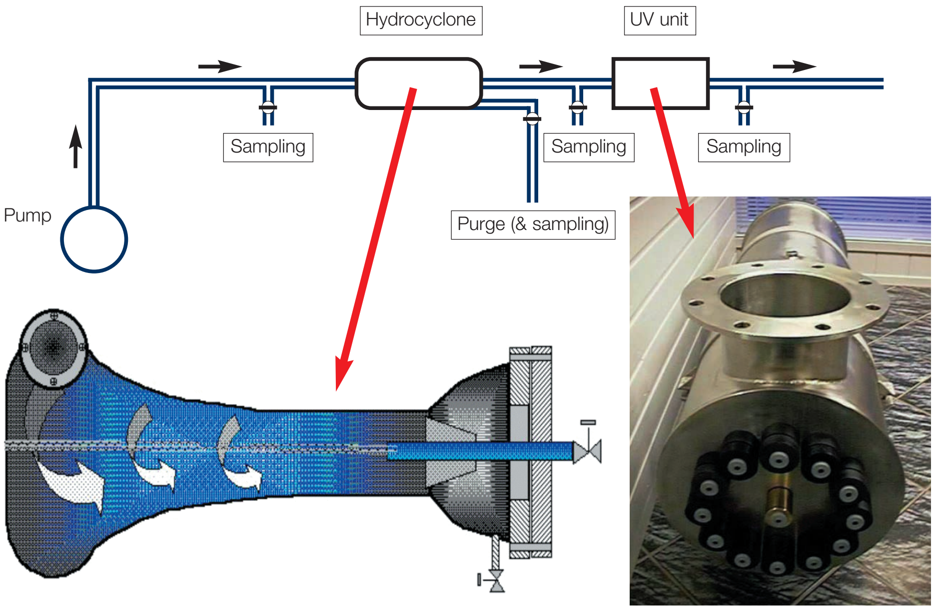


Figure 13 – The treatment system installed on the MV Regal Princess, incorporating hydrocyclone and UV chamber

down a tapering helical path. The lighter phase, in this case the water, migrates to the central core and the dense phase, in this case organic matter/sediment is expelled to the outer regions of the section. Each phase has an outlet with the dense phase being discharged overboard.

From the perspective of use on board ship, the absence of moving parts is a significant advantage with respect to maintenance and possible modes of failure. It has been reported that the present technology can cope with flow rates between 200m^3/hour and 3000m^3/hour depending on the equipment installed, which is far in excess of those associated with filtration.

A shipboard application, known to aim for future approval, is the treatment system installed on the MV Regal Princess of Princess Cruises in March 2000. This comprises a two-stage system, combining a hydrocyclone and UV chamber (see fig. 13).

Could these systems be applied to the major deadweight and freight carriers which carry considerable amounts of ballast water (see Table 1) On the evidence of existing technology, this could be rather difficult. It has been reported, however, that an American manufacturer has developed an ultra-cyclonic separator capable of delivering flow rates of over 10000m^3/hour. It is considered that research, including extensive testing, would be necessary for the development of reliable and effective systems with practical flow rates. Some typical capacities of the exclusive ballast pumps of various ship types are reported in Table 5. It is noted that all the reported examples have two exclusive ballast pumps.

Table 5
Typical capacity of the exclusive ballast pump

Ship type	Capacity (m^3/hr)
Handysize Bulk Carrier	800
Panamax Bulk Carrier	1000
Capesize Bulk Carrier	2800
Aframax Oil Tanker	1500
Suezmax Oil Tanker	1750
VLCC Oil Tanker	3000
LNG Carrier	2400

8 Conclusion

There will be very few deadweight and freight carriers which would pass with flying colours an assessment against classification, statutory and operational aspects, as those used in the study for the sequential method, using maximum lifetime loads and motions of the ship. The study identified the risks in respect of the sequential method and described options for mitigating these risks. If ballast exchange operations on existing ships, especially those utilising the sequential method, are carried out without understanding or controlling the risks, then the ship's safety could be endangered.

The Administrations' inability to multilaterally agree and define clearly the acceptable methods, procedure and criteria for ballast water management indicates that the problem is not an easy one to solve. However, this lack of decision making in the short-term could have long-term consequences for all parties concerned.

The industry should start looking for feasible solutions, which will be acceptable to all parties concerned, in particular Administrations and Operators. Solutions should not be imposed, but be part of a selection process that at the end of the day will satisfy the needs of the Administrations and still will be practical for the Operators.

The ideal ballast water management method would be one that is effective, safe and easy to use and relatively inexpensive to install and maintain. It can be observed that there is no single or simple solution apparent yet to prevent the transfer of harmful aquatic organisms. Understanding of risks and associated impact on the environment and the ship is considered imperative prior to the development of solutions.

The industry's commitment to standardise clear criteria for the assessment of ballast water management is, therefore, essential. Once this has been achieved, the procedure shown in fig. 14 could be followed for the preparation of a ballast exchange plan, identifying which method is used for various ballast tanks and ballast conditions. At the planning phase the user defines the criteria for compliance. Then the user follows several paths until a ballast exchange plan acceptable to all parties concerned is prepared.

It is noted that ships in-service often suffer damages and/or corrosion which could weaken the structural capability against loads generated during ballast exchange at sea operations. Therefore, when strength calculations are performed, consideration should be given to the present condition of the structure. Using the results and the general findings of the LR Study as reference, the user could select suitable ballast exchange methods, thus reducing the overall effort required to prepare an acceptable ballast exchange plan.

Regulations must make both socio-economic and techno-economic sense. In the case of ballast water management, the former has been dictated by the needs of societies that have been struck by the introduction of harmful aquatic organisms in their waters, subsequently affecting local environments. If the industry finds acceptable solutions that make techno-economic sense, then the regulations will be seen as mature and sensible. The aim of Lloyd's Register of Shipping is to assist the industry to find feasible solutions for all parties concerned.

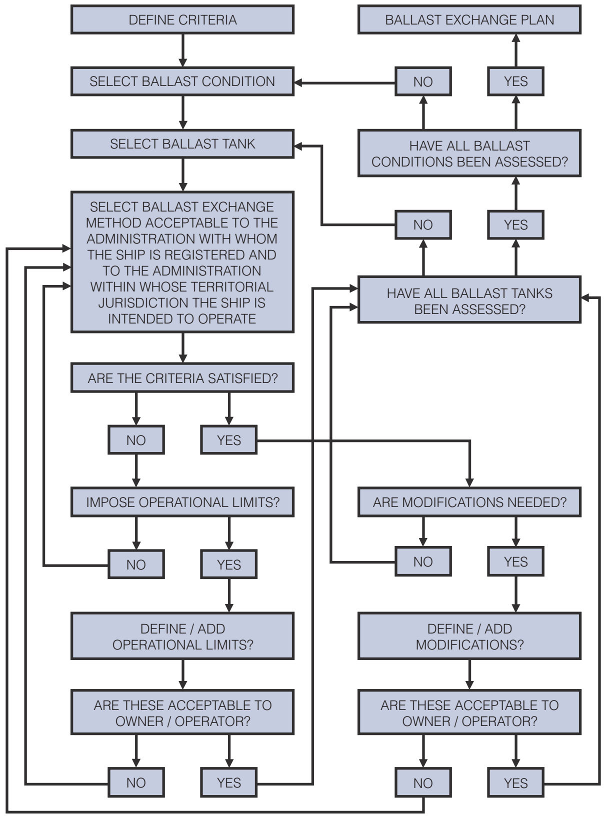


Figure 14 – Ballast exchange procedure

Acknowledgements

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Authors' Biographies

Author

Lefteris Karaminas is a Naval Architect who graduated from the University of Newcastle upon Tyne in 1985 and the following year he got a Masters in Shipping and Maritime Studies at Liverpool Polytechnic. In 1991, having previously gained wide experience through design, inspections, repairs and marine consultancy work in Piraeus, he joined Lloyd's Register as a Surveyor in the Technical Planning and Development Department. Since then he has been involved in rule development projects and provided shipbuilders, owners, external bodies and Lloyd's Register staff with advice on technical matters. In 1996 he obtained seniority and was appointed co-ordinator of rule development projects. In January 2000, following Lloyd's Register's restructuring, he was promoted to Principal Surveyor. His present responsibilities in the Research and Development Department of Marine Business cover ship strength aspects and the development of procedures. Other current duties include representation of Lloyd's Register on various committees and at international meetings and being a member of the Ship Emergency Response stand-by team. Lefteris is the Product Manager for Ballast Water Management Services.

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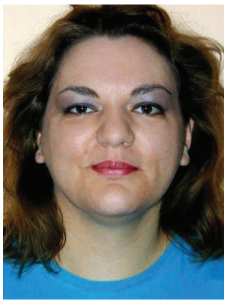

Katherine Mazdon is a Research Assistant in the Research and Development Department of Marine Business. In 1989, having previously studied office technology at the City of London Polytechnic, she joined Lloyd's Register in the Technical Planning and Development Department. Since then she has offered IT support in various research programmes and was responsible for co-ordinating the departmental migration to Windows 95. She has extensive knowledge of IT and foreign languages and was IT representative in the recent Lloyd's HQ relocation. Her present responsibilities include the production and co-ordination of the information on BWMP to be sent to outports and the development of part of the software to produce operational envelopes in the form of polar plots.

Paul Westlake completed a four year MOD(N) shipbuilding apprenticeship in 1988 and gained entry into the Defence Engineering Service as a bursaried student trainee. After graduating from the University of Southampton with a first class degree in Ship Science in 1991 he began a fluid mechanics Ph.D as a research assistant within the same department. The focus of study was the prediction of the fluid disturbance produced by a body moving in a vertically stratified fluid. This work was supported by the Defence Evaluation and Research Agency. In 1993 he commenced lecturing as a teaching fellow and became a lecturer in 1996. The philosophy doctorate was awarded in 1997. In 1998 he entered the Technical Planning and Development Department of Lloyd's Register of Shipping as a seakeeping specialist. His primary research field is the deterministic and probabilistic non-linear motion and load response of rigid and elastic structures in waves. He represents LR on several international research committees and chairs the Co-operative Research Ships hydroelasticity working group.

Ballast Water Management

Overview

- Why manage ballast water?
- Methods, concerns and implications
- How LR can help

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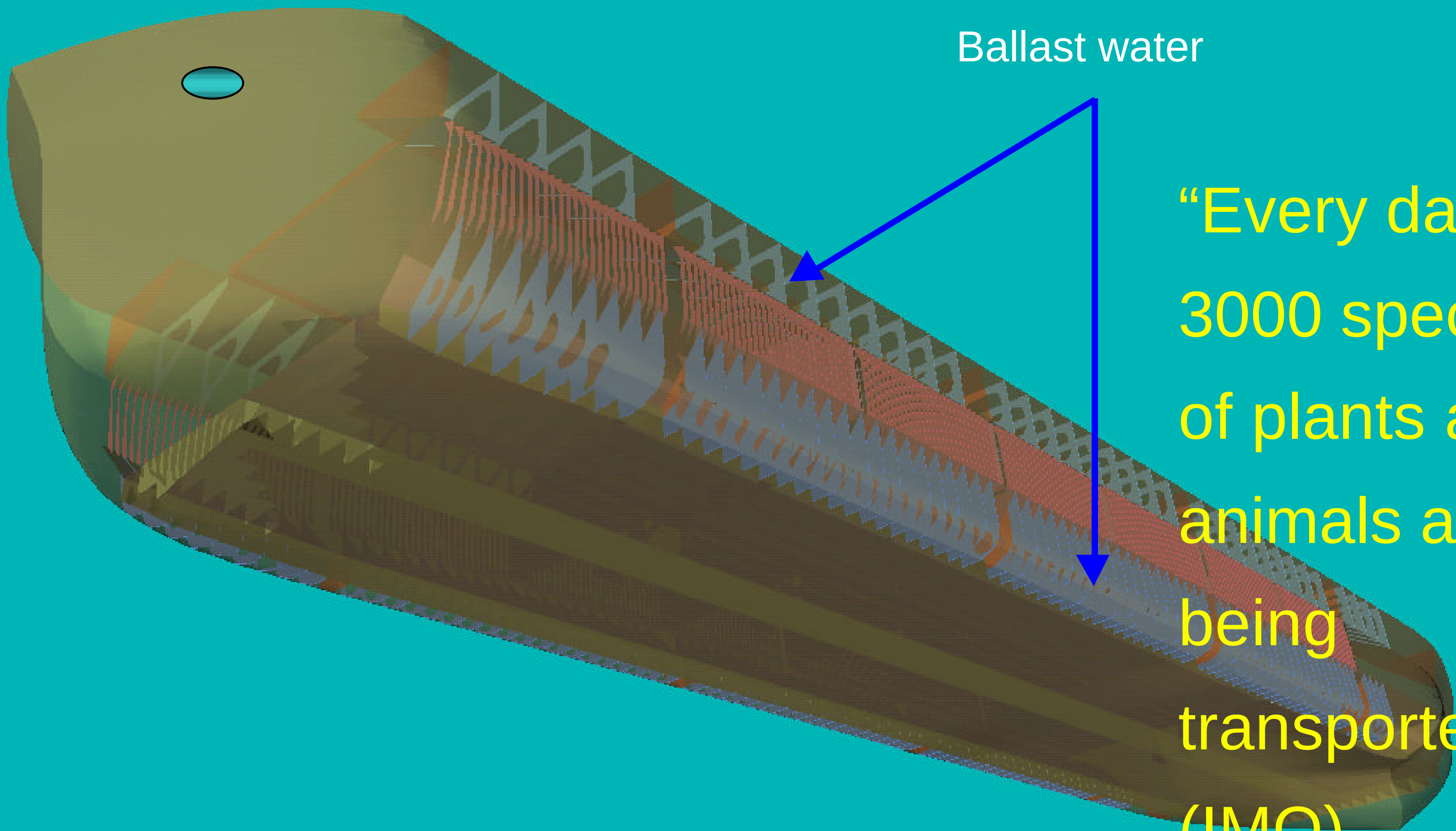
Why manage ballast water?

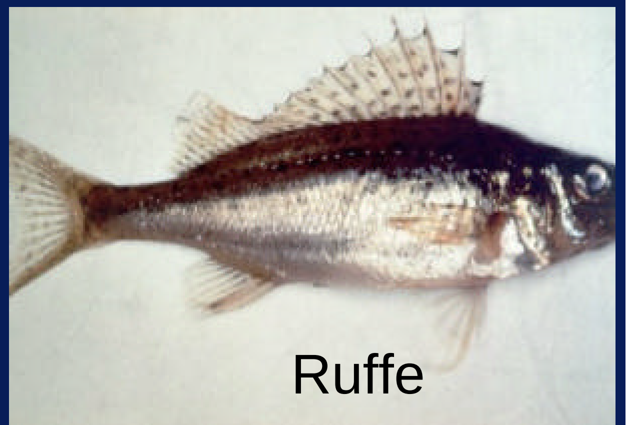
"Every year, the world's fleet moves 10 billion tonnes of ballast water around the world" (IMO)



"Every day, 3000 species of plants and animals are being transported" (IMO)

Lloyd's Register

Why manage ballast water?



Why manage ballast water?

- Certain Port States have introduced local regulations requiring BWM, in particular:
  - USA & Canada, Australia & New Zealand
  - Israel, Panama, Argentina and Chile
- IMO have introduced guidelines for BWM (IMO Resolution A.868(20), November 1997)
- A new legal instrument covering BWM is expected around 2002-2004

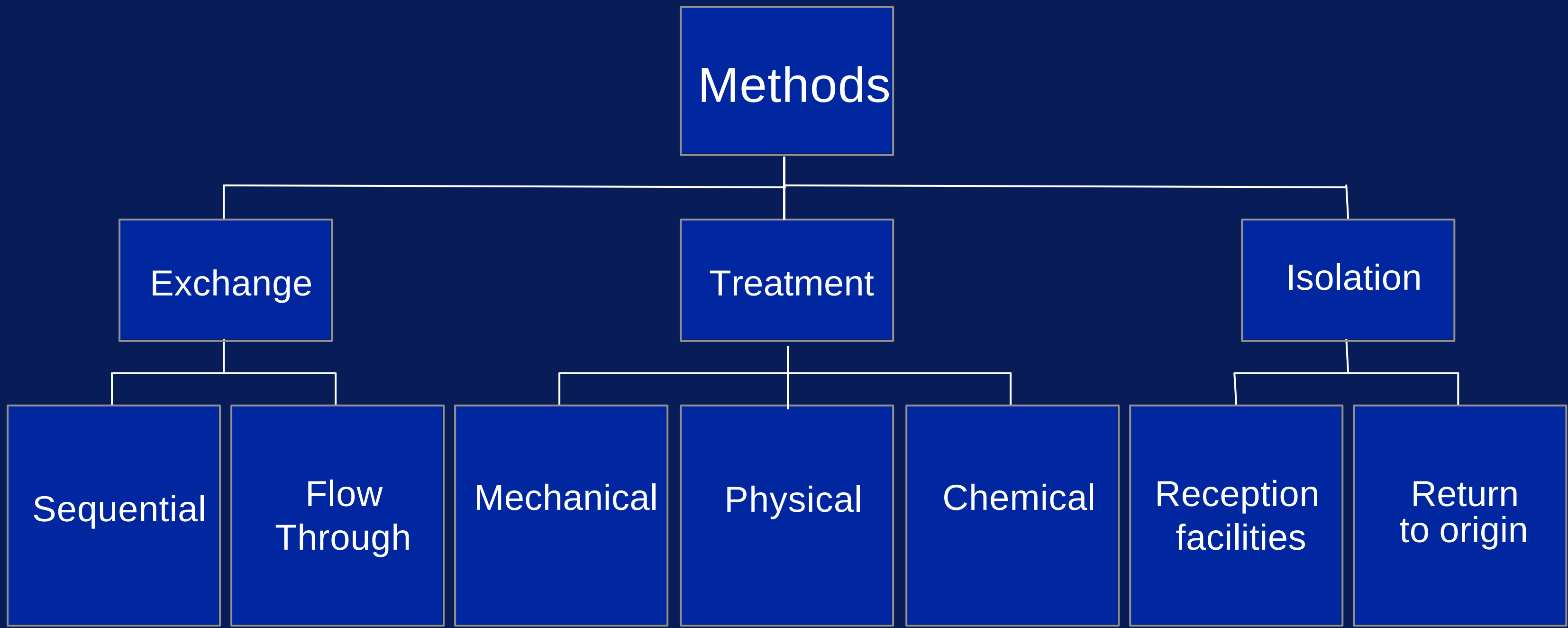
Lloyd's Register

Overview

- Why manage ballast water?
- Methods, concerns and implications
- How LR can help

Lloyd's Register

Managing Ballast Water



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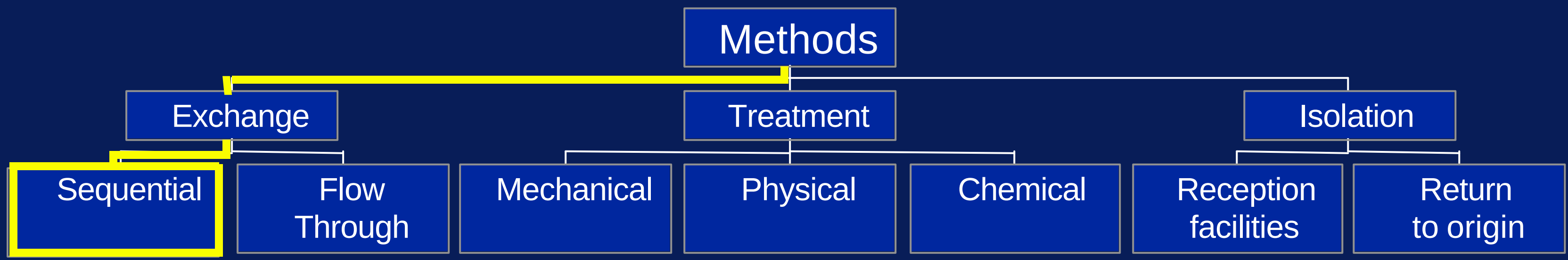
Managing Ballast Water



- Method:
  - complete discharge and refilling with open-ocean water
- Advantages:
  - effective exchange of almost complete volume, pumping and piping have only moderate increase in workload
- Disadvantages:
  - requires careful planning to avoid exceeding permissible limits for strength, stability and excessive fwd or aft trim

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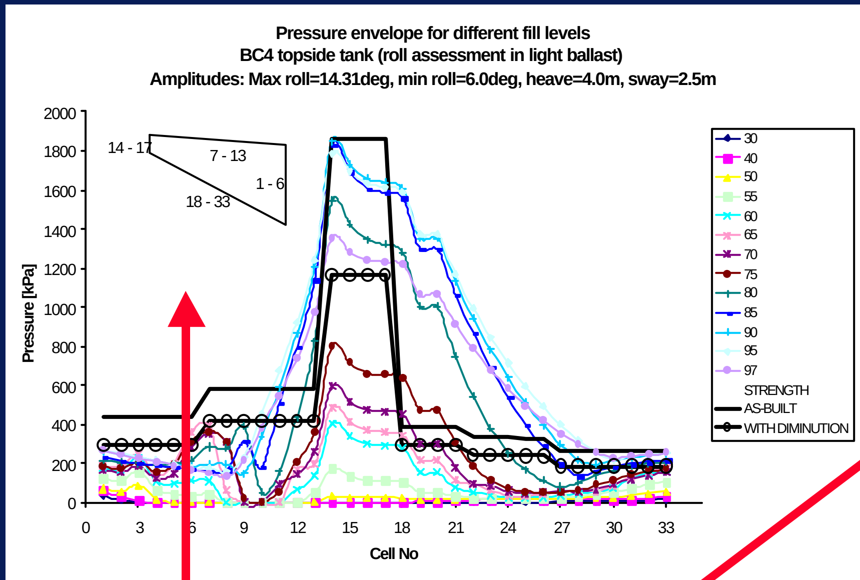
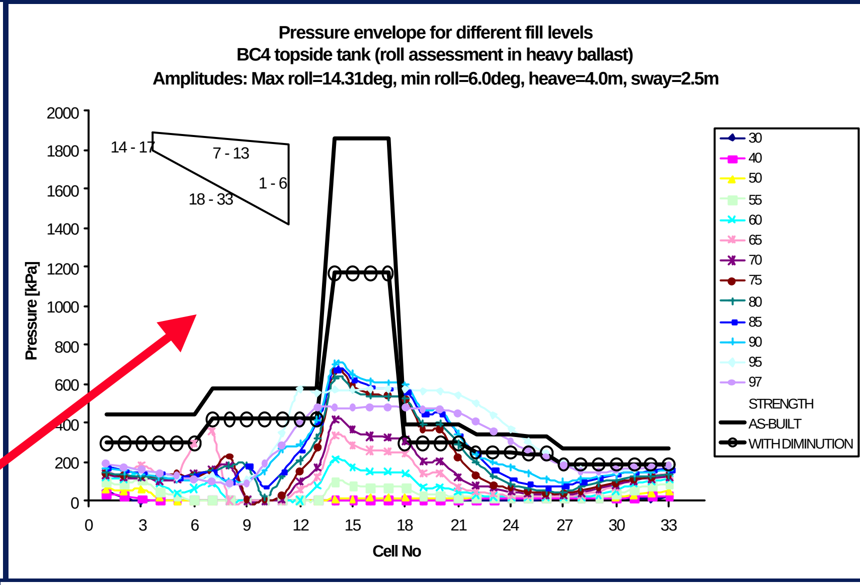
Dynamic loads - Sloshing
Example: Capesize bulk carrier

LIGHT BALLAST CONDITION

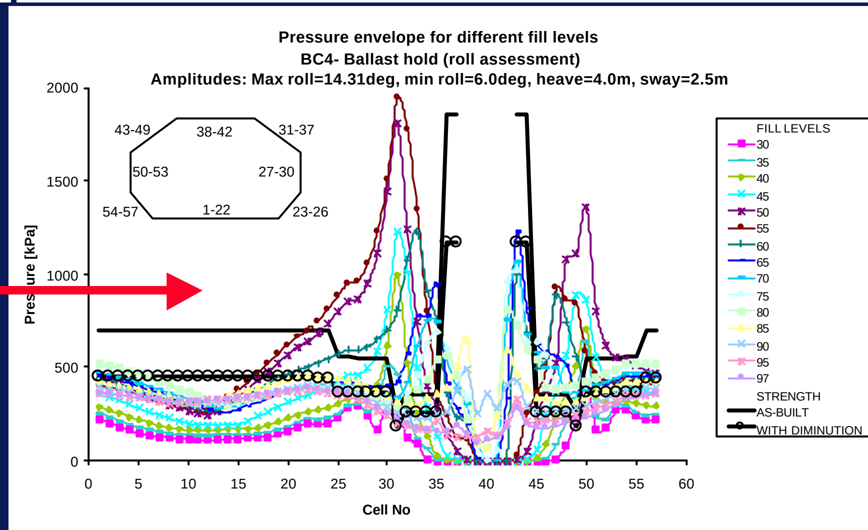


HEAVY BALLAST CONDITION



TOPSIDE TANK

BALLAST HOLD



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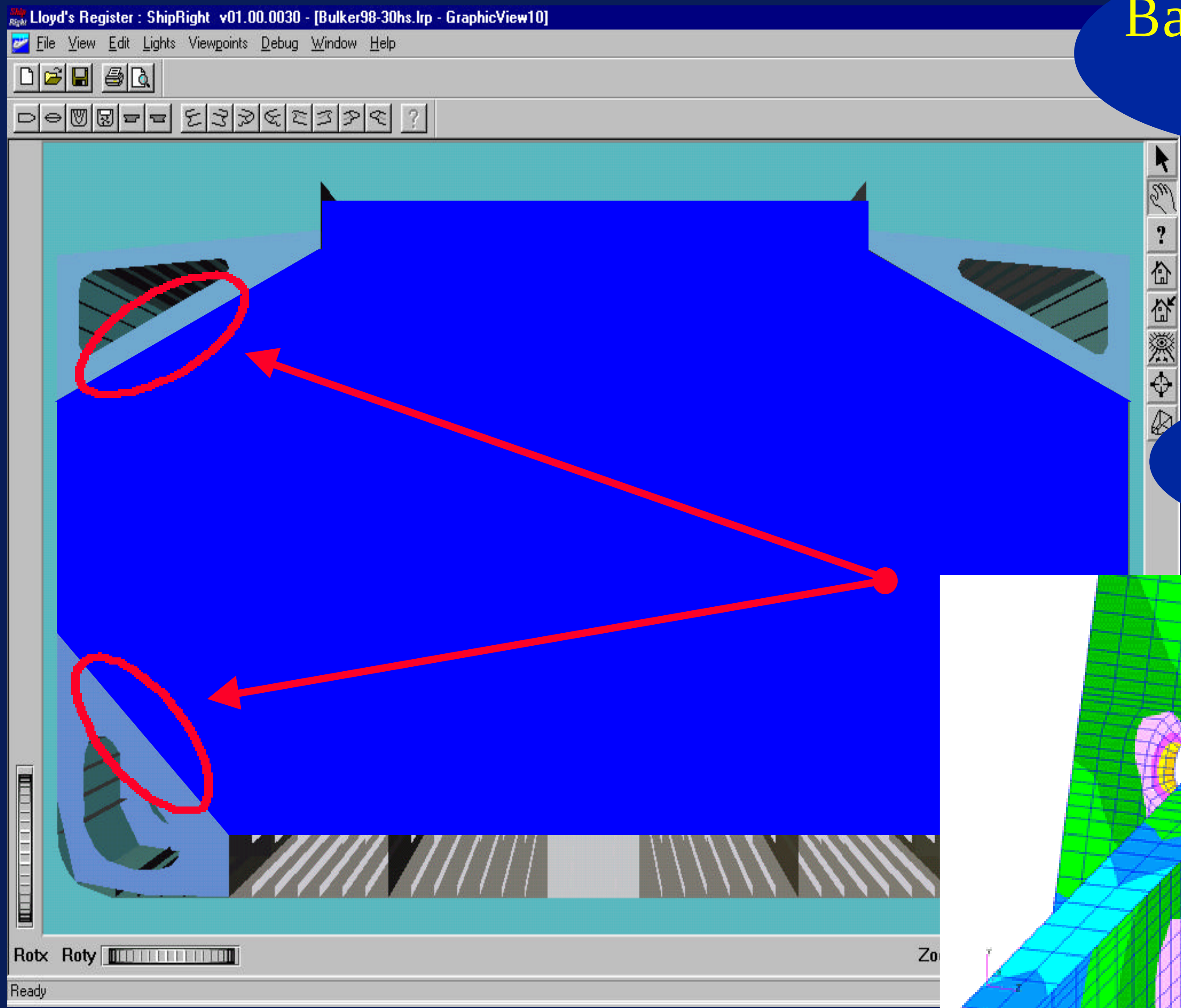
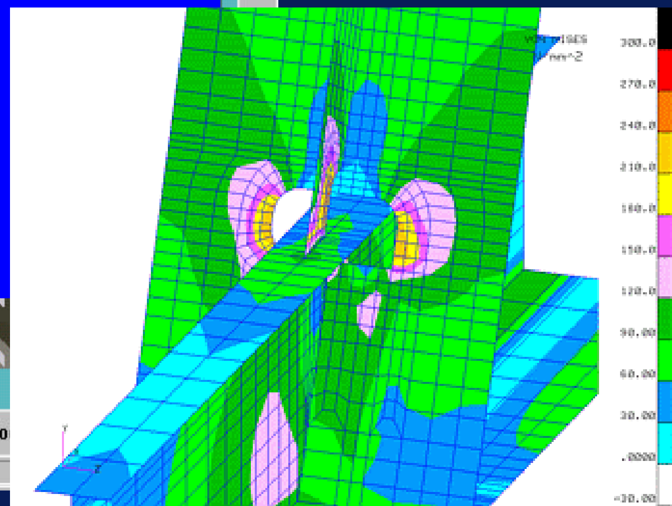
Dynamic loads - Ballast inertia
Bulk carriers

Ballast inertia scenario

Ballast hold

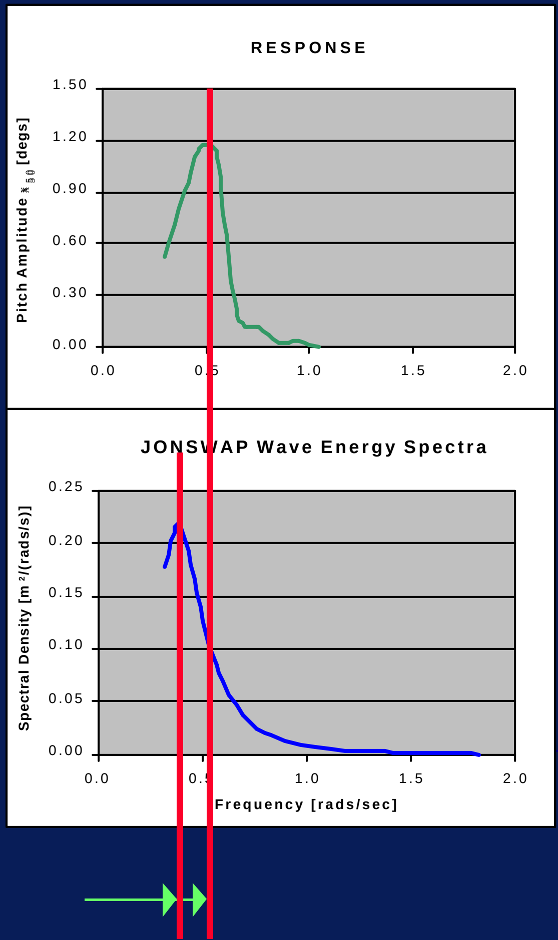




Option: Sequential method with Operational envelope

Hull Form
+
Weight Distribution

Sea Spectrum



Short-term response can be maximised in respect of Modal Period

Short-term response to irregular waves

Duration of Operation
+
Limiting Response
+
Probability of Exceedance
+
Peak Enhancement Factor

Permissible Wave Height
+
Iteration for Speed and Heading

Limit Card

NEW SOFTWARE: **LIMITS**

Lloyd's Register

Operational Envelope

Sample Limit Cards

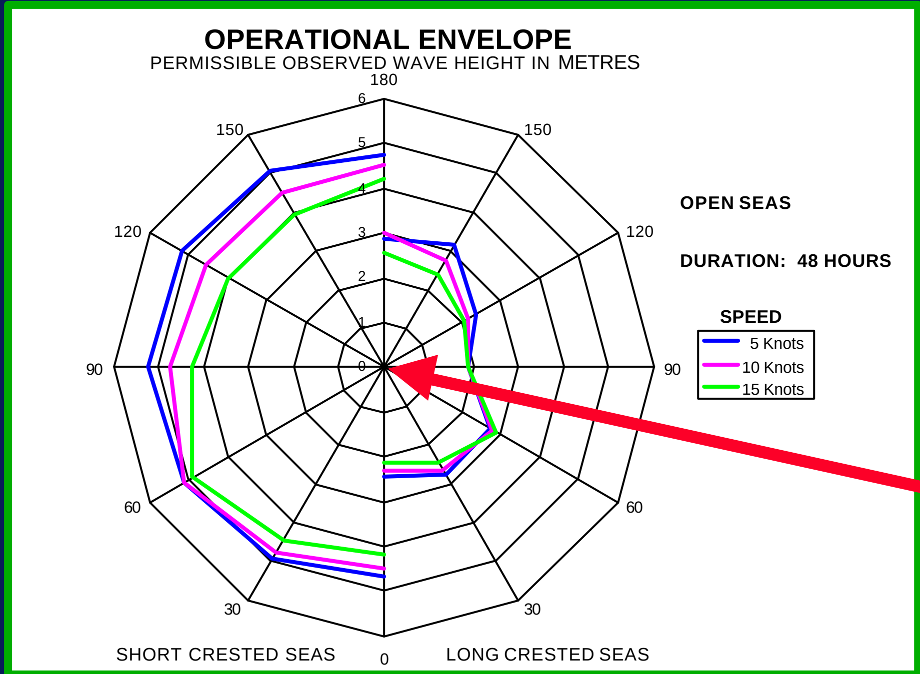
Other RAOs	Speed

Pitch	Speed

Vertical Shear Force	Speed

Vertical Bending Moment	Speed		
Heading [Degs]	5 knots	10 knots	15 knots
0	3.3	3.1	2.9
30	3.6	3.5	3.3
60	5.2	5.2	5.2
90	6.9	6.3	6.0
120	7.1	7.0	6.7
150	4.2	4.4	4.4
180	3.7	3.8	4.0

Operational Envelope



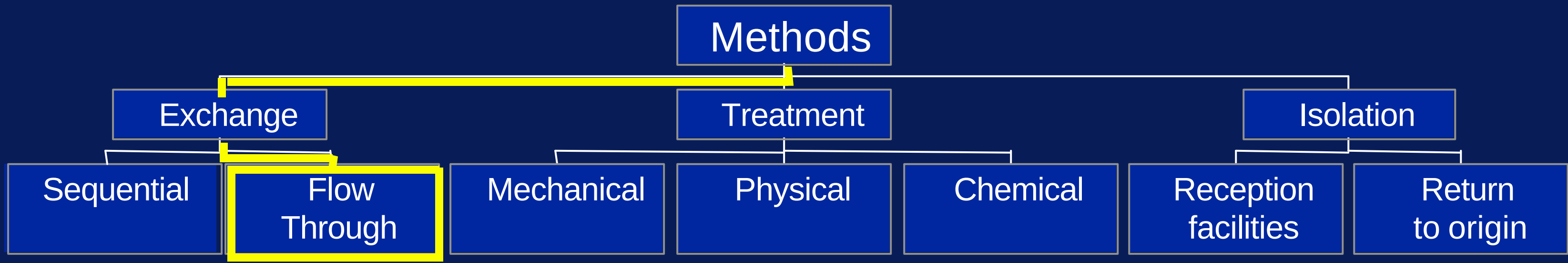
CALM SEA AS PER W.M.O.

Sequential method: Under-pressure

- Under-pressure is created by a large drop in pressure, due to the rapid change in the contents of the tank
- For sequential systems, the increased frequency of partial ballast water discharges by gravity is likely to result in more damage incidents

- For sequential systems, it is recommended that ballast holds and large ballast tanks are equipped with pressure/vacuum valves

Managing Ballast Water



- Method:
  - open-ocean water is pumped into a full tank allowing it to overflow (require several times the volume of tank)
- Advantages:
  - easy to follow, does not affect longitudinal strength, stability or trim of ship
- Disadvantages:
  - not all tanks are designed with a head to the top of overflow, damage due to over pressurisation, double bottom and peak tanks difficult to flush through, pumps and piping experience increased workload, not suitable in cold environments

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Flow-through method

Unless operational limits are specified, i.e. sea states, flow-through method would be, in general, needed for:

- ballast hold of bulk carriers (heavy ballast condition)
- topside tanks of bulk carriers (light ballast condition)
- ballast tanks of single skin tankers (without transverse ring web structures)
- fore and aft peak tanks of bulk carriers and tankers (without a centreline wash bulkhead or a centreline ring structure or horizontal ring structures)

Flow-through method

PROVISION: Tank scantlings are designed with a head to the top of the overflow

This provision is of particular importance to:

- topside and hopper tanks of bulk carriers NOT being interconnected
- peak tanks with spaces above and where the overflow is located at the top of these spaces

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Flow-through method

- inlet and outlet piping connections should be located as far apart as practicable, to improve circulation
- a larger discharge pipe is to be located in a remote position opposite from the filling pipe and a smaller discharge pipe is to be located in a closer position to the filling pipe, to improve circulation
- double bottom and peak tanks may need additional pipework to improve mixing conditions

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Flow-through method

- Air pipes on ballast tanks are intended to allow air to escape, or enter, a tank during ballast operations and are usually of flat disc type or ball float.

- They are not meant, or indeed capable of handling, large scale discharge of water ballast which can result due to continuous ballast pumping as would be experienced for flow-through systems. Air vents with automatic closing devices are recommended.

Flow-through method

- the total sectional area of the ballast water discharge pipes should be not less than two times the sectional area of the filling pipe
- avoid the use of two ballast pumps simultaneously
- distribute one ballast pump to several tanks
- air pipe vents may need to be removed to handle large scale discharge of water ballast due to continuous ballast pumping
- access hatches to topside tanks may need to be opened to permit overflow of water and to avoid large pressure increase

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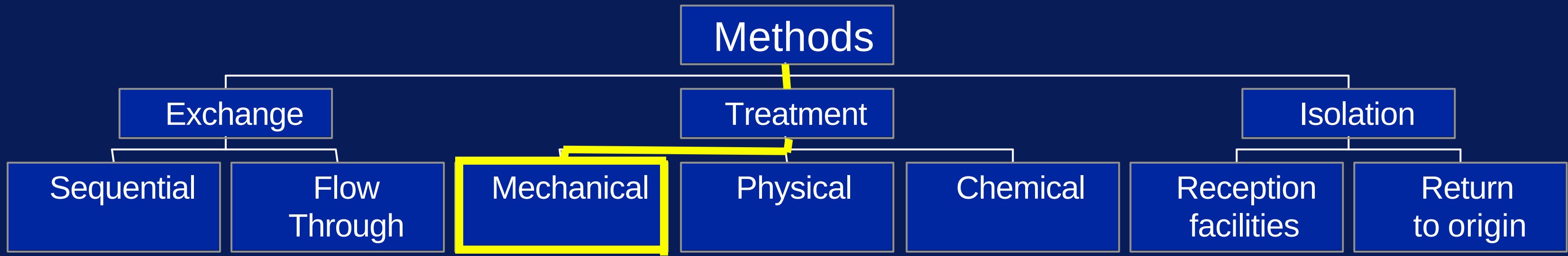
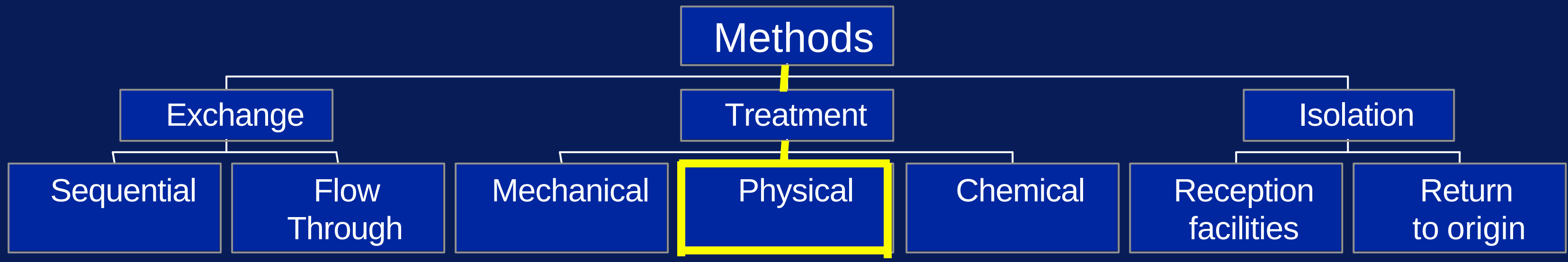
Managing Ballast Water



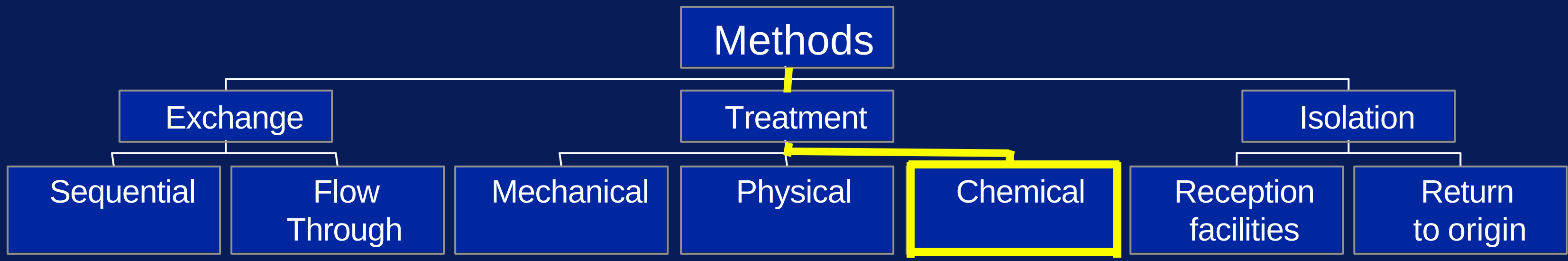
- Method:
  - filtration equipment or a cyclonic separator device
- Advantages:
  - does not effect strength, stability or trim of ship and is not weather dependent
- Disadvantages:
  - not effective for small organisms, not currently suitable for large volume ballast movements

Managing Ballast Water



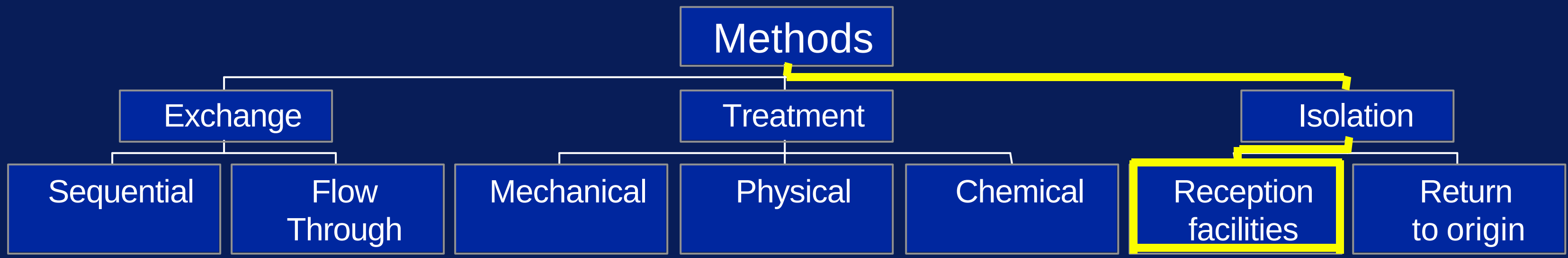
- Method:
  - thermal, ultraviolet or ultrasound equipment
- Advantages:
  - does not affect strength, stability or trim of ship and is not weather dependent
- Disadvantages:
  - some organisms may be resistant, additional pipework, possible adverse effect on tank coatings, pipes and pumps, space availability

Managing Ballast Water



- Method:
  - Disinfectants, organic biocides, electrolytically generated copper and silver ions
- Advantages:
  - does not affect strength, stability or trim of ship and is not weather dependent
- Disadvantages:
  - health and safety aspects of crew, effect on tank coatings, pipes and pumps, discharge of treated water may not be permitted

Managing Ballast Water



- Method:
  - discharge ballast water to reception facilities provided by ports
- Advantages:
  - avoids overboard discharge into local waters and does not effect strength, stability or trim of ship
- Disadvantages:
  - limited ports will provide reception facilities, ships will spend more time at port with an associate workload increase in the piping and pumping systems

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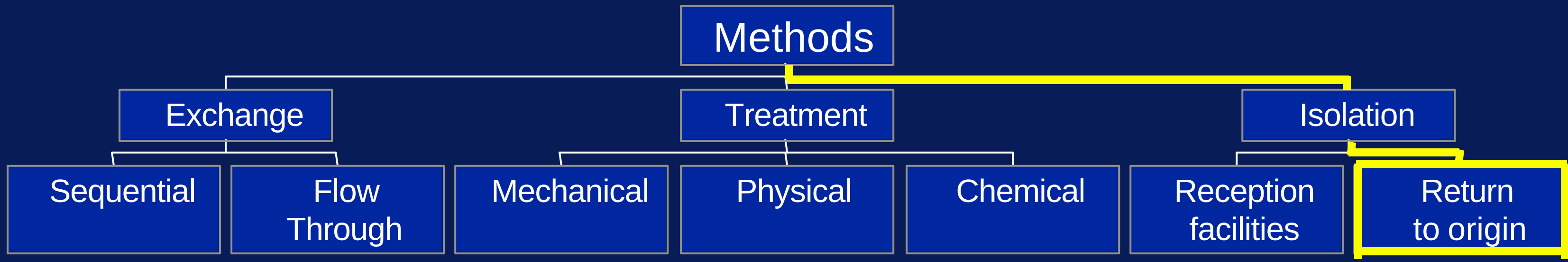
Managing Ballast Water



- Method:
  - keep ballast water on-board
- Advantages:
  - water is only discharged in originating location. Does not effect strength, stability or trim of ship
- Disadvantages:
  - Impractical in most cases, reduces cargo carrying capacity

Managing Ballast Water - Summary

- A number of different methods, each with advantages and disadvantages
- Only exchange methods are currently widely recognised
- Research on-going into treatment methods
- At present, it is not clear which method(s) any port state administration will be willing to accept in the future

Lloyd's Register

Overview

- Why manage ballast water?
- Methods, concerns and implications
- How LR can help

How LR can help

- Preparation of ballast water management plans by LR - Optional Service

- Preparation of BWMP by Client using the Lloyd's Register Model Ballast Water Management Plan

- Review and approval of BWMPs, as necessary, according to the Acceptance Criteria of Lloyd's Register of Shipping for the Assessment of Ballast Water Management Plans, on the basis of IMO Resolution A.868(20)

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How LR can help ... continued

- Ballast Water Management Plan Certificate
  - BWMP(T) treatment method
  - BWMP(F) flow-through method
  - BWMP(S) sequential method with or without operational envelope
  - BWMP(S+F) combined sequential and flow-through
  - BWMP(S,F,S+F) stand alone sequential and flow-through and combined
- Training Programmes for Shipowners, Consultants and Shipyards

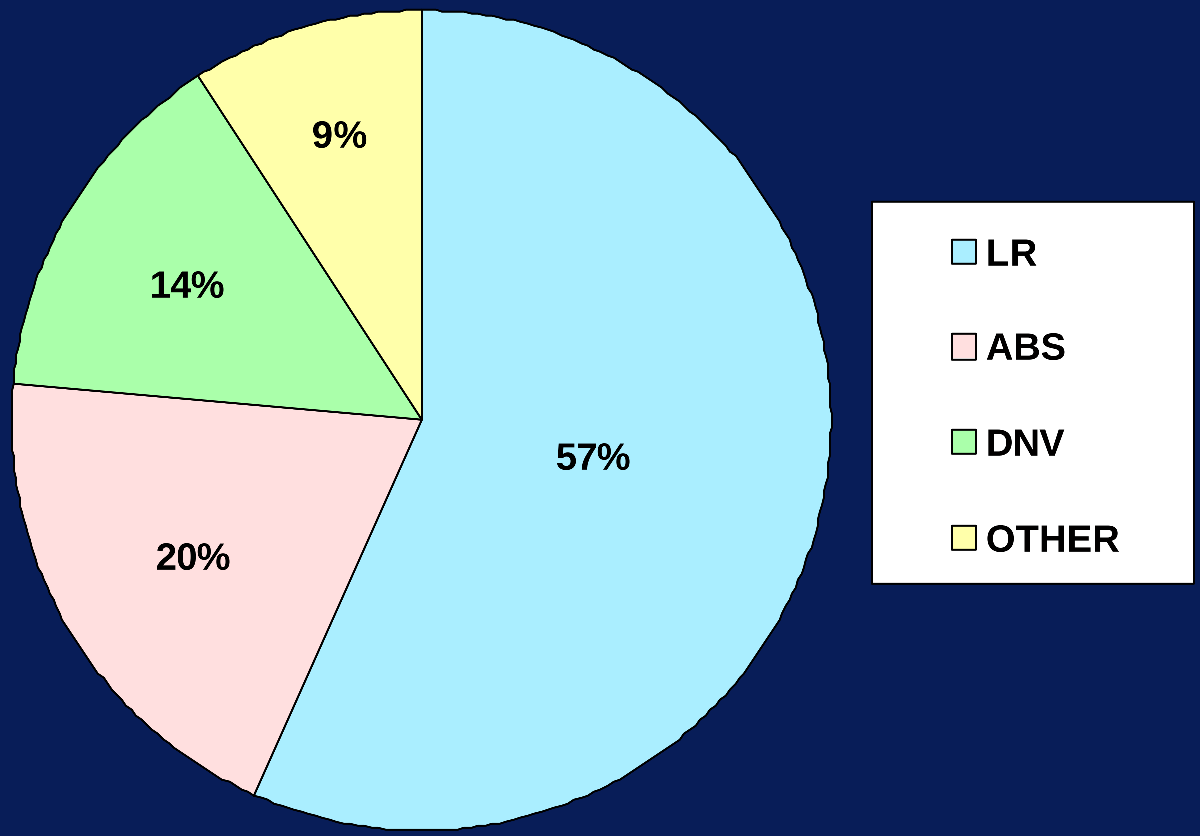
Lloyd's Register

What has LR done in the last year?

- Devised and conducted 12 exclusive BWM workshops with over 200 attendees in 4 locations around the world
- Attended a series of international conferences
- Produced the new Lloyd’s Register Model Ballast Water Management Plan, which is given complimentary in electronic format to those who request the Lloyd’s Register BWM services
- Developed specifications for new construction projects to ensure the owners get the best deal for bulk carriers, tankers and container ships

Lloyd's Register

Ships contracted to Lloyd's Register Ballast Water Management Services by July 2001, included ships of other class



64% Wet sector + 36% Dry sector

Lloyd's Register

Conclusion

- There is no single ideal solution
- Methods, procedures and acceptance criteria are still awaited by IMO, in the wake of unilateral action taken by several countries
- A BWMP should be produced for ballast exchange operations and approved by a Recognised Organisation , as necessary
- An early decision should be made on what method(s) are to be used for new buildings
- LR, having undertaken an extensive study, having developed relevant assessment criteria, certification and training schemes, having reviewed and approved plans of all major ship types, can assist Owners and Operators accordingly

Lloyd's Register

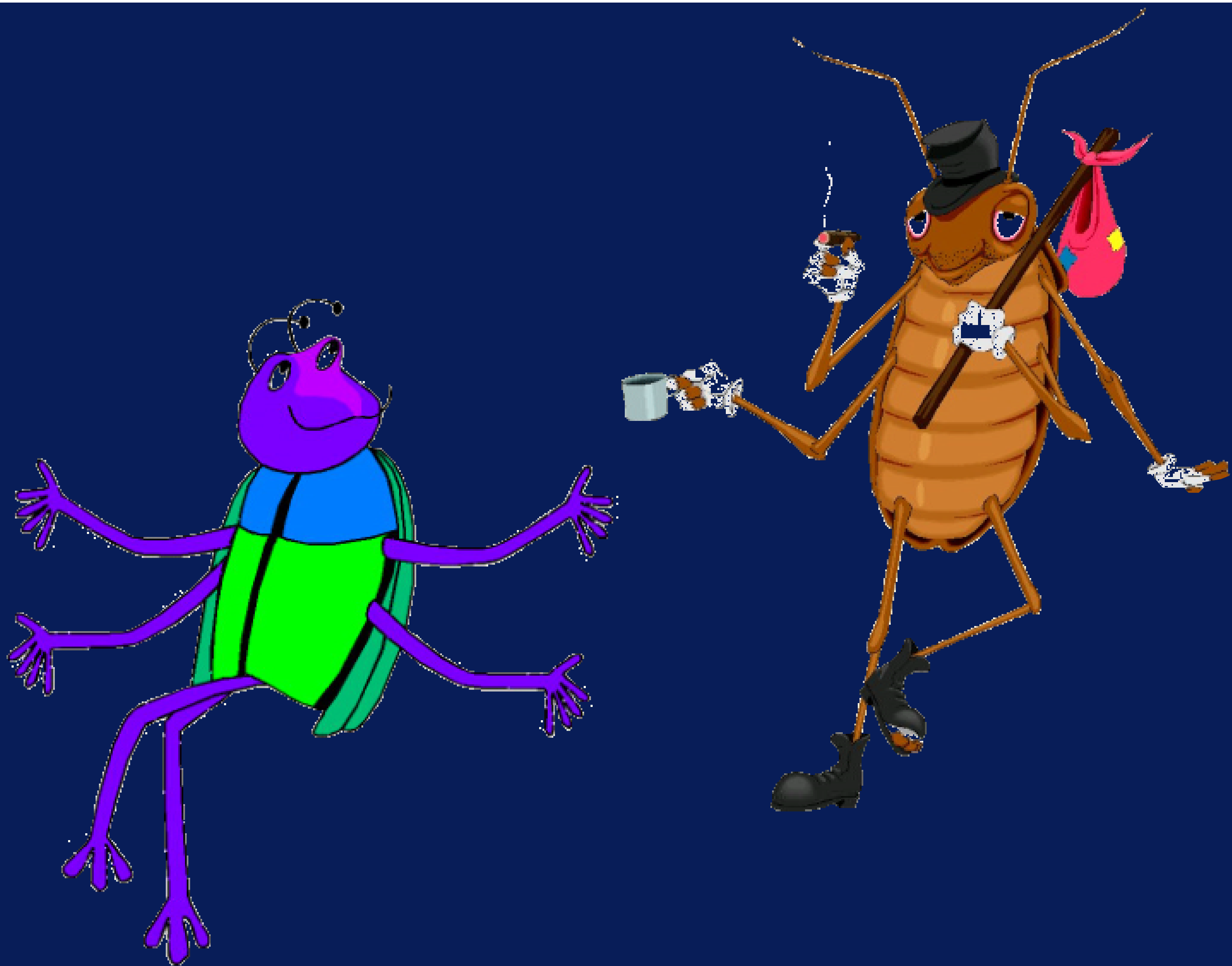
Ballast Water Management

Thank you

- Enquiries
- Quotations
- Model Plan
- Certification
- Training
- BWM Paper

bwmp@lr.org

Lloyd's Register



"Would have been here sooner but the Master exchanged ballast at sea"

Lloyd's Register

LR study

26 ships:

- 3 single skin tankers
- 1 double side tanker
- 4 double hull tankers
- 4 single side skin bulk carriers
- 5 container ships
- 2 liquefied natural gas carriers
- 2 self-discharging bulk carriers
- 3 oil-bulk-ore carriers
- 2 general cargo ships

Light and heavy ballast conditions

Longitudinal strength

Intact stability

Departure and arrival

Bridge visibility

Minimum draught forward

Propeller immersion

Dynamic Loads

Lloyd's Register

CURRICULUM VITAE

NAME:	**Marcel Pätzold**
DATE OF BIRTH:	07.12.1965
NATIONALITY:	German

CURRENT DUTIES AND RESPONSIBILITIES

Basic Grade Engineer Surveyor, LR Bremerhaven Office. Involved in ship classification and industrial services. Responsible for machinery new construction and periodical surveys.

Lead Auditor for ISM (International Safety Management) Certification. ARN 224.

CAREER SUMMARY

Served an engineering apprenticeship at H.W. Mohr Industrial Tools, sea service apprenticeship on general cargo vessels as multipurpose seaman at Leonhardt & Blumberg Shipping Company, Hamburg.

Studies at Technical University of Applied Sciences for Marine Engineering in Bremerhaven. Promoted to I. Engineer "CIW" on deep sea steam and motor ships of unlimited power. Follow on studies at Nautical University of Applied Sciences in Elsfleth for deep sea Master Licence "AGW"

Sea service as 3 rd Engineer at Leonhardt & Blumberg Shipping Company, Hamburg and as 2 nd Engineer and 2 nd Nautical Officer at Hapag Lloyd Container Linie, Hamburg.

Sales Engineer at MaK Maschinenbau GmbH & Co KG , Bremen for medium speed marine diesel engines.

Joined Lloyd's Register in January 1999, Bremerhaven Office as Engineer Surveyor.

QUALIFICATIONS

ACADEMIC:	Hochschule Bremerhaven (University of Applied Science) 1992-1995 Chief Engineers Licence for Steam and Motor Ships of unlimited power Degree in Marine Engineering, Diplom Engineer (Dipl.-Ing.) Fachhochschule Elsfleth (University of Applied Science) 1995-1996 Master Licence for Steam and Motor Ships unrestricted voyage.

PROFESSIONAL EXPERIENCE

Service with Lloyd's Register since 1999:

October 1999 - Date	Engineer Surveyor at Bremerhaven LR Office. Classification and statutory surveys and inspection of components for industrial use. Periodical and repair surveys on Container Ships, Ro-Ro Vessels and Refrigerated Vessels.

Professional Experience prior to joining LR:

1998	MaK Maschinenbau GmbH & Co KG, Bremen. Sales Engineer for mediun speed marine diesel engines
1997-1998	Hapag Lloyd Container Linie GmbH, Hamburg. Sea Service as multipurpose Engineer Officer/ Nautical Officer on Panmax Container Vessels (Diesel Engines).
1996-1997	Reederei Leonhard & Blumberg, Hamburg. Sea Service as Engineer Officer on Panmax Container Vessels (Diesel Engines).
1990-1992	Reederei Leonhard & Blumberg, Hamburg. Sea Service apprenticeship as multipurpose seaman on Container Vessels and Refrigerated Vessels.
1986-1990	Werkzeugbau H.W. Mohr, Bönningstedt. Apprenticeship as Toolmaker for punching and cutting tools.

Specialised on the fields of: N.A.

Other relevant data: Member of the Board of the German Association of Marine Engineers "Wieland", Bremerhaven

Training Courses:

- NDE Foundation Course
- Visual Weld Inspection
- Welding Technology
- Inspection of GRP Construction
- Inspection of Materials
- ISO 9000 Auditor Course
- ISM Auditor Course

April 2001

CURRICULUM VITAE

Dr. Matthias Voigt, *Environmental consultant*

Born in 1959 in Berlin.

Matthias Voigt has been working as an self-employed environmental consultant in Germany (1986 - 1988 and 1992 -current) and in Australia (1989 - 1991). His work focused on the aquatic environment in both, the marine and fresh water ecosystems. He has worked on a wide range of subjects: environmental impact studies, ecological projects, studies of inland and coastal fisheries. In 1993 he started consulting for inland and coastal fisheries, as well as for the industry.

Matthias has been involved in the Ballast Water issue since 1997. He became a partner in the EU Concerted Action on "Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters". Within the Concerted Action he concentrated on treatment options for ballast water.
With his company, he developed a benchmark test for the efficiency of possible chemical treatment options for ships' ballast water and is a consultant for the maritime and chemical industries.

Matthias holds a Ph.D. from the University of Queensland, Australia (1993), where he has worked on water quality monitoring and the assessment of pollution effects on ectoparasites of estuarian fish. He also holds a M.Sc. (1986) from the Institute of Marine Research, University of Kiel (Germany) in the subjects of Fisheries Biology, Zoology and Oceanography.

Abstract

Dr. Matthias Voigt
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Tel: +49 4326 987 37, e-mail: m.voigt@drvoigt-consulting.de

"Management Options for Ballast Water Operations"

Ballast water is used to stabilise vessels at sea. Globally, it is estimated that about 12 billion tonnes of ballast water are transferred each year. It has been demonstrated in numerous studies, that this water may contain aquatic organisms from many different groups, ranging from cysts of microscopic toxic algae to different taxa from the planktonic and benthic communities (crustacean, mussels, snails, polychaet worms and fish). In addition, human pathogens such as *vibrio cholerae* (cholera), have been found in the ballast water.

As a result, many introductions of non-indigenous organisms in new locations have occurred in recent years, often resulting in severe consequences for the local ecosystem and in tremendous costs for the local industries.

This underlines the need for a sound ballast water management practice. Current options for reducing the risk of introduction of non-indigenous species with ships' ballast water include different risk assessment tools as well as various ballast water management strategies, that can be carried en route or in land based facilities.

This paper presents a brief overview on possible ballast water management strategies in ports and onboard ships and will focus on their practicability.

Management Options for Ballast Water Operations

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Abstract

Ballast water is used to stabilise vessels at sea. Globally, it is estimated that about 12 billion tonnes of ballast water are transferred each year. It has been demonstrated in numerous studies, that this water may contain aquatic organisms from many different groups, ranging from cysts of microscopic toxic algae to different taxa from the planktonic and benthic communities (crustacean, mussels, snails, polychaet worms and fish). In addition, human pathogens such as *vibrio cholerae* (cholera), have been found in the ballast water.
As a result, many introductions of non-indigenous organisms in new locations have occurred in recent years, often resulting in severe consequences for the local ecosystem and in tremendous costs for the local industries.
This underlines the need for a sound ballast water management practice. Current options for reducing the risk of introduction of non-indigenous species with ships' ballast water include different risk assessment tools as well as various ballast water management strategies, that can be carried en route or in land based facilities.

This paper gives an overview on possible ballast water management strategies in ports and onboard ships and looks into the "human factor" in ballast water operations.

Introduction

Globally, about 12 billion tonnes of ballast water are transferred each year and it has been demonstrated in numerous studies, that many organisms from different trophic levels can be found in ballast water tanks, ranging from vira to metazoa as well as algae and various cysts (Carlton 1985, 1987, Carlton & Geller 1993, Carlton et al. 1995, Hallegraeff & Bolch 1991, 1992, Hedgpeth 1993). One reason for this great variety of taxa are the three different "habitats" that can be found in a ballast water tank:

- the walls of the tank,
- the ballast water itself,
- and the sediment.

As ships travel faster and faster, the survival rates of species carried in ballast tanks have increased. As a result, many introductions of non-indigenous organisms in new locations have occurred in recent years (Tab. 1), often resulting in severe consequences for the local ecosystem.

Table 1: Known introductions of non-native species (number of species) from different regions.

Region	No. of Species	Author
British waters	53	Gollasch (1998)
Ireland	24	
Germany	100	
Sweden	70	
Mediterranean Sea	145	
San Francisco Bay	212 (230)	Cohen & Carlton (1995)

Among those introduced species, there are numerous examples where the introduction has caused considerable damage to the environment and or to the local economy (Ojaveer & Lumberg, 1995, McCarthy & Khambathy, 1994, Hallegraeff & Bolch, 1991). Further examples for introductions to Europe have been detailed by Gollasch et al. (1999).

This underlines the need for a sound ballast water management. Current options for preventing the introduction of non-indigenous species with ballast water include the exchange of the ballast water in deep ocean, as well as various physical and chemical treatments of the ballast water en route or in land based facilities to kill the living organisms.

In recent years, a lot of information on possible technical solutions for the ballast water problem became available. However, every ballast water management option – and may it be the most effective – is always carried out by people. Therefore, its acceptance by the people who actually work with those options is just as important.

This "human factor" is most important for ship based treatment and management options. It is well known, that ship's crews are under constant pressure. While the number of crew members is kept as low as possible, and the technical skills required are constantly increasing, and the factor time matters more in more in modern shipping.

Any sincere and responsible ships' master will ask himself the two major questions:

What did I fill in last time? And Did I get away with it?

These are the first steps towards a "creative" way of filling out forms, and that is nothing but human.

As for the harbour masters, they run not only a port in the tough market of shipping, but they also have to look at their "environmental image", which becomes more and more an important factor in today's competition. And there are the politicians and regulating bodies, who are very concerned about their local environment and who try to protect their natural resources.

And last but not least, there are the companies, which own the vessels. All of them try to show a high environmental awareness and they want to be "better than the rest" by showing that they do even more than just to comply with existing rules and regulations.

In the context of ballast water, this means that a number of different groups of people are approaching the problem from their very personal and / or professional perspective. But in the end, it's the ships' crew and the local administrator who have to deal with it.

If we look at the different regulations that are already in place in different countries, it is even more understandable that "creativity" is widely spread. Specially ships that travel on different routes face the fact, that they may have to comply to very different ballast water regulations. This does truly not help to increase the acceptance of ballast water management options.

A solution to this problem could be, that the IMO member states agree on a common ballast water management, making it much easier for the national authorities and the other parties to adopt.

We must ask us some questions:

Can we really expect from a captain and his first engineer to decide which of the three methods of ballast water exchange is the most suitable for their ship and their route?

How can you train a crew, when language barriers interfere?

Three different methods of ballast water exchange at sea have been identified:

1. the **sequential method**, in which ballast tanks are pumped out and refilled with clean water;
2. the **flow-through method**, in which ballast tanks are filled with new ballast water in deep seas, allowing the water to overflow. At least 3 times the tank volume should be pumped through the tanks:
3. The **Brazilian dilution method**, where ballast water is pumped into the top of tanks, and simultaneous unloaded through bottom of the tank, keeping a constant ballast water level in the tank.

For all methods of exchange it has to be taken into account, that the ballast water may represent up to 50 % of the total cargo capacity. This means, that considerable time may be needed to complete the ballast water exchange or an appropriate sequence of it.

There are further restrictions on the exchange of ballast water:

avoid ballasting in	"hot spot" areas
	in areas of sewerage discharges
	in waters with high sediment loads
	no ballasting at night

In any case, the aspects of ship's safety in relation to the exchange of ballast water at sea are of paramount importance and they have been addressed by the IMO's Maritime Safety Committee (MSC). No ballast water exchange should be undertaken in circumstances which may threaten human life or safety of the ship (critical situations of an exceptional nature, force majeure due to stress of weather).

So we need alternative solutions of the problem. They could be applied during **different stages of ballast water operations**:

1. **On or before departure from port**

   uptake of treated ballast water from special shore-based facilities.

2. **During the voyage between ports**

   Apart from the exchange of the ballast water (see above), various options have been proposed for the onboard treatment of ballast water.

3. On arrival at port of call.

Ballast water discharge to reception facilities

Ballast water discharge to barges

non-release of ballast water

sediment removal and disposal ashore (only during dry-dock periods)

Comprehensive overviews on physical and chemical treatment options have been compiled by Gollasch (1997), Grenman et al. (1997). However, not all of the proposed methods seem to be suitable for onboard application. Voigt (2000) gave an indication of the practicability of various treatment methods. There are two groups of treatment: physical treatment options and chemical treatments.

In general, any physical treatment will remove the organisms with different filters or gravity separation, or it will attempt to kill the organisms by changing the physical properties of the water (e.g. heat treatment). While these methods are relatively simple to operate, they do not effectively reduce the risk of introductions as stand-alone methods.

And for the chemical treatment options, there are some general requirements that any chemical treatment of ballast water should follow: it should to be safe and environmentally sound and all components have be fully biodegradable. When released, it should not cause any damage to the environment.

The advantage of most of the chemical treatments is, that the substances can be added easily to the ballast water, when it is taken on board. However, one of the shortcomings of any chemical treatment is, that with every – even with partly - exchanges of ballast water, the entire volume of water in the ballast tank has to be treated. Otherwise the dilution of the substances with the remaining water would result in insufficient dosing of the chemicals. This limits the applicability of chemical treatments to those types of ships, that do not exchange their ballast water for a minimum of 1 to 2 days (e.g. bulk carriers and oil tankers). In contrast, container vessels frequently exchange only parts of their ballast water when loading or unloading in the ports of call. As a consequence, a stand-alone chemical treatment is limited to certain typs of ships.

So we have to look into combined treatment systems, what makes the operation and management of ballast water treatments even more difficult.

Every ballast water treatment should require as little as possible labour. Unfortunately, the more simple the operation of equipment is, the more technique is involved in most cases. A single button is pushed and a number of processes will start automatically.
But what if they don't? Here comes the very important part of crew training and redundancy in the game.
One solution to this misery could be to keep ballast water management options as simple as possible. And this should account for the entire process, from the reporting form to the equipment installed.

But it's not only the ship-based ballast water treatment that encounters many problems. The land-based treatment is also not an easy task. Any land-based management options has to account for different types of ships and their different ballast water operations (management plans) as well as for the specific situation of the port. For example, ballast water reception facilities are useful only in those areas of the harbour, where ships are present that can use those facilities. This applies only to those vessels, that can pump their entire ballast water through a single outlet. Ships that discharge the ballast water many by gravity – as many RO-RO-ships do – would have a problem with such an option.

Summary

The successful and effective management of ballast water operations can only by achieved, if the "human factor" is also taken into account. From the technical side, a flexible "tools box" of different management approaches is needed, that addresses the specific needs of the individual ship (ballast water management plan) and the specific problems of the port / flag states ("hot spots" of introductions) as well as locale, regional and global aspects of introductions of non-indigenous species. Therefore, the management of ballast water operations can only be successful as an integrated concept. Such a task can only be achieved as a co-operative effort involving all stakeholders (ship owners, harbour masters, locale administration, engineers) as well as the scientific community.

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Management of
Ballast Water Operations

Matthias Voigt
Environmental Consultant, Germany

- **Introduction**

  General aspects

- **What can we do to reduce the risk?**

  Current regulations

  Ballast water management options

- **Summary**

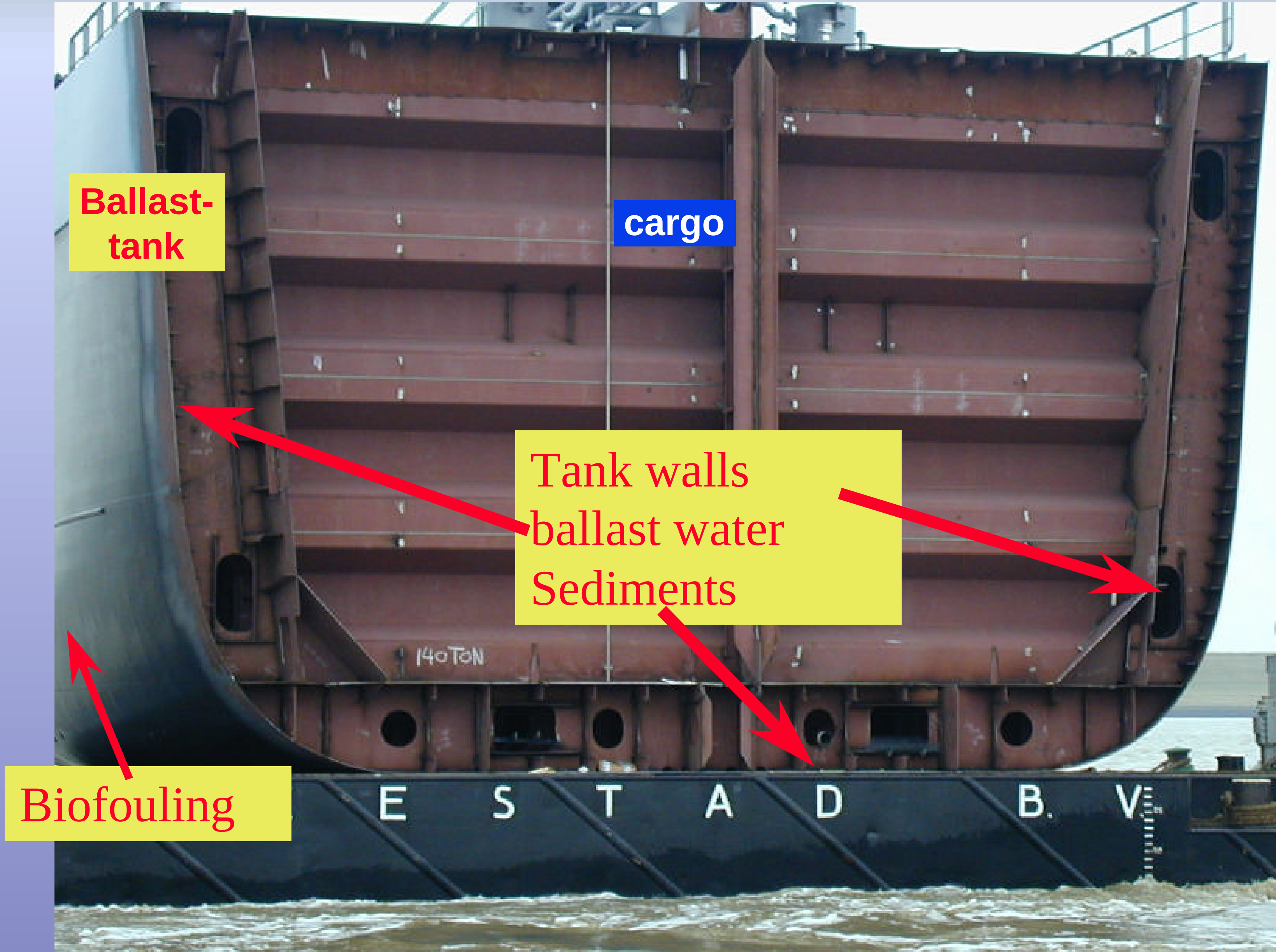
  Integrated Ballast Water Management Concept

General Aspects

Globally, about 12 billion tonnes of ballast water are transferred each year.

Organisms from different trophic levels can be found in ballast water tanks: vira, algae, metazoa and cysts.

Modern ship design increases the survival rates of species in ballast tanks.
New introductions are reported each year.


Ballast-
tank
cargo
Tank walls
ballast water
Sediments
140TON
Biofouling
E S T A D B. V.

What can we do to reduce the risk?

Current Regulations

no discharge of BW or exchange of BW in deep ocean

Some examples

Argentinia	**in-tank treatment by adding chlorine if ship arriving from aereas where cholera is endemic**
Australia	**all ships from overseas have to do BW exchange**
Canada	**BW exchange at depth > 2000 m; no discharge into port until samples are taken**
Chile	**all ships ballasted with sea water: BW exchange**
Israel	**all ships: BW exchange / uptake off continental shelf**

Current Regulations

New Zealand	all ships carrying BW from other territorial waters: BW exchange or fresh water ballasting
UK	Orkney Islands; all ships wishing to discharge BW: discharge to reception facilities (capacity of 40,000 barrels/h)
USA	California - all ships: BW exchange outside EEZ (environmentally sound treatment) Great Lakes – all ships: BW exchange outside US EEZ or in designated areas retain BW on board

Ballast water management options

1. On or before departure

avoid ballasting	in "hot spot" areas in areas of sewerage discharges in waters with high sediment loads ballasting at night
Uptake of treated BW	from special shore-based facilities.

2. During the voyage between ports :

BW exchange	**sequential method** **flow-through method** **Brazilian dilution method**
Physical treatment	**filtration** **gravity separation** **heat treatment** **UV radiation**
Chemical treatment	**tank wall antifouling coatings** **oxidising agents / chemicals** **biocides**

3. On arrival

BW discharge to reception facilities
BW discharge to barges
non-release of ballast water

[Sediment removal and disposal ashore]

Responsibilities of the ships‘ master

Ballast water management onboard of the ship:

Ballast water management plan
on board and implemented?
BW exchange method
Location of exchange,
Start and end points (degrees and minutes)
Volume exchanged
% exchange of total ballast
[Treatment method]
Responsible officer's

Responsibilities of the ships‘ master

Ship’s crews are under constant pressure

Any sincere and responsible ships’ master will ask himself the two major questions:
What did I fill in last time?
And did I get away with it?

Can we really expect from a captain and his first engineer to decide which of the three methods of ballast water exchange is the most suitable for their ship and their route?

From a port masters view

From a port masters view

1. Technical information from each vessel:
   - Name
   - Typ of ship
   - IMO/Lloyds No.
   - Gross tonnage
   - Arrival at port, date and time
2. Ballast water history of the ship:
   - Total Ballast on Board
   - Total Ballast Capacity
   - Number of Ballast Tanks
   - Ballast water uptake: Port, Country, Date
   - Ballast Water Source: Date of uptake, last location of uptake, Vol. taken up

Ports have to be compatible in the tough market of shipping

They also have to look at their “environmental image”

Summary

The Management of Ballast Water

successful management of ballast water operations can only by achieved, if the "human factor" is taken into account
All stakeholders (ship owners,harbour masters, local administration, engineers,scientists) have to be included in the process.

A flexible "tools box" is needed, that addresses

- **the specific needs of the ship (BW management plan)**
- **specific problems of the port / flag states (hot spots)**
- **locale, regional and global aspects of introductions of non-indigenous species.**

What are the costs?

Who has to pay for this?

What are the costs, if we do not act?

Just when I knew all the answers...

..they have changed the question!

CURRICULUM VITAE

Dr. Stephan Gollasch
GOConsult

Dr. S. Gollasch was involved in the first European ship sampling programme on ballast water, tank sediments and ship hull fouling (1992-1996). His PhD is world-wide the first thesis based on ship sampling. He further prepared, together with colleagues from 5 countries, the first risk assessment study for species invasions in the Baltic Sea, carried out for the Nordic Council of Ministers. Due to the international aspect of introductions Dr. Gollasch became a member of several international working groups: ICES (WGITMO, SGBOSV and SGMBIS), IMO (MEPC) and is co-chairman of the BMB (NEMOs).
Since 2001 he is the chairman of the WGITMO and SGBOSV. He was involved in the EU Concerted Action "Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters", MAS3-CT97-0111, as co-chairman.
The study was completed in January 2000. Currently Dr. Gollasch coordinates a bilateral research initiative together with a Canadian colleague. The key objective of the study is to assess the survival of species in ballast water en-route. Beside laboratory and desk studies he spent more than 100 days at sea during several ballast water sampling programmes.

Abstract

Dr. Stephan Gollasch
GOConsult

"Survival of Species in Ships Ballast Water"

In recent decades, ballast water discharges have increased world-wide, especially in and near most major ports. As a result the probability of successful transfer and establishment of exotic species remains high.

Although many data reviews and sampling programs have been carried out, little information exists on the survival rates of species during ship journeys. Detailed information on the survival rate of species would assist in evaluating the risk of unintentional introductions. During previous research initiatives, the survival of planktonic organisms in ballast water tanks was studied by accompanying vessels on long-term and short-term voyages. Most species and individual organisms decreased in number over time, although a species of harpacticoid copepod increased dramatically in one tank. Some species survive ballast water voyages of several weeks up to months.

Survival of Species in Ships Ballast Water

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Introduction

Nonindigenous species have been transported with ballast water and associated sediments since the 1870s, and probably longer as fouling organisms attached to the ship´s hull since shipping began. Ballast water is pumped on board to stabilise and trim the vessel and to submerge the propeller when ships are not fully loaded. It has been estimated that the major cargo vessels annually transport nearly 12 billion tonnes of ballast water world-wide, indicating the global dimension and concern of the problem. Organisms are taken on board unintentionally when pumping up the water and associated suspended solids. Some of the individuals may survive voyages of several months duration (Carlton et al. 1995, Gollasch 1996). It has been demonstrated that, on average, 3,000 (Carlton & Geller 1993) to 4,500 species (Gollasch 1996) are transported between continents by ships each day. Each species discharged with ballast water in coastal waters and ports of call outside their native range has the potential to establish a self-sustaining population and to threaten populations of any native species, fishing and aquaculture industries, tourism and public health.

In cooperation with six European countries (England, Finland, Ireland, Scotland, Sweden, Lithuania and the International Maritime Organization (London)), Germany coordinated the two year European Concerted Action study: "Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters". The global dimension of the problem was addressed by inviting experts from all over the world (e.g. the Americas, Mediterranean Countries and Australia) to Concerted Action workshops. The estimation of survival rates of taxa in transit was one of the key objectives of this study. The ballast water was sampled daily during several ship voyages enabling documentation of the survival rate over time.

Material and Methods

A number of ship sampling programmes have been carried out in the past, but nevertheless there is a lack of data on the survival rates of species in ballast water during ship voyages. This report summarises the results of the following voyages:

(a) St. Petersburg (Russia) to Lisbon (Portugal) on a research vessel,
(b) Cork (Ireland) to Sture (Norway) accompanying an oil carrier,
(c) Kaohsiung (Taiwan) to Hamburg (Germany) on a container ship and
(d) during a Black Sea voyage of a research vessel from Odessa (Ukraine) to Constanta (Romania) to Varna (Bulgaria) and back to Odessa (Tab. 1).

Preliminary results of all voyages have been published elsewhere (Gollasch et al. 2000a+b, Olenin et al. 2000) and are summarized here for comparison.
All ballast tanks investigated were sampled on a daily basis. On all ships the samples were taken by lowering a zooplankton net (mesh size 55 µm) with a cone-shaped opening (cone-opening diameter 9,7 cm, net diameter 25 cm) into the ballast tank. The varying net haul depth is indicated below.

Tab 1: Details of the accompanied vessels and the ballast tanks investigated.

	St.-Petersburg – Lisbon	Cork – Sture	Kaohsiung – Hamburg	Odessa – Constanta – Varna
Ships name	Sibiryakov	Nordic Torinita	Pusan Senator	Georgij Ushakov
Type of ship	Research vessel	Oil tanker	Container vessel	Passenger, Research vessel
Duration [days]	13	2.7	26	4
Ship size [DWT]	3,442	108,682	63,654	1,420
Maximum volume of ballast on board [t]	268	43,818	18,473	124

Sampling route St. Petersburg – Lisbon

This ballast water study was carried out during a cruise organised by the Russian State Hydrometeorological University (RSHMU, St. Petersburg) on the research vessel SIBIRYAKOV leaving St. Petersburg on the 22nd of July 1998 calling at the port of Lisbon. On the 28th of August 1998 the vessel arrived back in St. Petersburg. The voyage was undertaken within the framework of the "The Baltic Floating University (BFU)" programme. The ballast water was taken on board in the Northern Baltic Sea on the 25th of July 1998 and was sampled daily until the 3rd of August 1998.

This research vessel was not equipped with designated sea water ballast tanks. The aft peak tank, usually carrying freshwater as ballast, was filled with ocean water for the purpose of this experiment. This small tank (11 tonnes), located under the ship's main-propeller shaft, was sampled through an opened manhole. The net haul depth was 2 m.

Sampling route Cork – Sture

The usual shipping route of the oil tanker NORDIC TORINITA is between ports along the North Sea coasts. The ship transports crude oil from Norway to various European ports and on its return trips to Norway it is in ballast, i.e. no cargo is transported. After departing from Whitegate Terminal Cork, Ireland on October 8th 1998, the vessel proceeded northwards through the Hebrides, sailed around northern Scotland and crossed the North Sea. It arrived at Sture Oil Terminal, Norway on 11th October 1998. The duration of the voyage was 64 hours and 30 minutes (2.7 days).

The vessel has 12 ballast tanks (aft peak tank, fore peak tank and 10 side tanks). The side tank port side with a capacity of approximately 2,700 tonnes was sampled. The depth of the net hauls was 2.5 m.

Sampling route Kaohsiung – Hamburg

The container vessel PUSAN SENATOR is usually in service westbound around the world calling at ports in Asia, Europe and North America. The vessel was accompanied for 26 days on its route from Kaohsiung (departure 21st of May 1999) travelling via Hong Kong, Singapore, passing through the Suez Canal, visiting Rotterdam (Netherlands) and terminating its journey in the German port of Hamburg on the 14th of June 1999.

The ballast tank sampled was the side tank port side with a capacity of 350 tonnes enabling a net haul depth of 3 m.

Sampling route Odessa – Constanta – Varna - Odessa

This voyage was planned as a mission of the International Maritime Organization (IMO) to increase public awareness in the Black Sea region regarding nonindigenous species introduced by shipping and to sample the ballast water en-route. The four day voyage began

in Odessa on September 14th 1999. The ship called at the ports of Constanta and Varna and returned to Odessa after four days on September 17th 1999.
The vessel was equipped with 5 ballast tanks (aft peak tank, fore peak tank and side tanks). The aft peak tank, available for sampling in the engine room of the vessel, had a capacity of 12 tonnes. The net haul depth was 1.5 m.

Results

The numbers of zooplankton taxa and individuals caught during all ballast water sampling voyages are given according to the relevant shipping route:

Sampling voyage from St. Petersburg to Lisbon (Fig. 1, Tab. 2)
The zooplankton in the ballast water taken on board in the Northern Baltic Sea showed a decrease of both taxa and individuals during the 10 day sampling trial. Initially, 10 taxa and approximately 300 specimens were caught in 100 l of ballast water. During the first two days the number of individuals and taxa decreased by half from day one. On day three, more individuals were caught. After day three, the density of organisms decreased towards the end of the sampling period. On day eight only five taxa were found in very low numbers, whilst the previous day, two taxa were determined. From day eight onwards no living zooplankton specimens were found (Fig. 1, Tab. 2).

Tab 2: Species sampled from the ballast water during the voyage St. Petersburg to Lisbon according to their daily occurrence in the samples.

	Duration (days)											
Taxon	0	1	2	3	4	5	6	7	8	9	10	11
Rotatoria												
Keratella cohlearis	x	x	x					x				
Rotatoria, indet.	x											
Crustacea												
Cladocera												
Bosmina coregoni	x											
Evadne nordmani	x											
Podon polyphemoides	x	x										
Copepoda												
Acartia longiremis	x	x	x	x	x	x	x	x				
Eurytemora hirundoides	x	x	x	x	x	x	x	x				
Temora longicornis	x		x				x	x				
Harpacticoida undet.	x	x	x	x		x						
Mesocyclops leuckarti	x		x					x				
Total number of taxa found	**10**	**5**	**6**	**3**	**2**	**3**	**3**	**5**	**0**	**0**	**0**	**0**

Sampling voyage Cork to Sture (Fig. 2, Tab. 3)
During the voyage the number of zooplankton taxa decreased continuously. From the 14 taxa found on the first day only nine survived by the end of the short-term voyage. Towards the end of the sampling programme there was a sharp decrease in the survival rate of taxa. The number of specimens increased from day one (approximately 2,000 individuals/100 l) to day two (more than 2,500 individuals/100 l). The third sample revealed less than 1500 individuals/100 l and the last sample contained approximately 750 individuals/100 l indicating the high mortality in the ballast water. At the end of the investigation, the rate of decrease of specimens was much higher than at the beginning (Fig. 2, Tab. 3).

Tab 3: Species sampled from the ballast water during the voyage Cork (Ireland) to Sture (Norway) according to their daily occurrence in the samples.

	Duration (days)			
Taxon	0	1	2	3
Mollusca				
Bivalvia, larvae, indet.	x	x	x	x
Gastropoda, larvae, indet.	x	x	x	x
Crustacea				
Copepoda				
Acartia clausi	x	x	x	x
Temora longicornis	x	x	x	x
Paracalanus parvus	x	x	x	x
Calanus finnmarchicus			x	
Oithona similis	x	x	x	x
Oithona nana	x	x	x	x
Oncaea sp.	x	x	x	x
Corycaeus sp.	x	x		
Harpacticoida, indet.	x	x	x	x
Cirripedia				
Balanus sp. (nauplii)	x	x		
Decapoda, larvae, indet.	x	x	x	
Polychaeta, larvae, indet.	x		x	
Chaetognatha				
Sagitta sp.	x		x	
Tunicata				
Oikopleura sp.		x		
Total number of taxa found	**14**	**13**	**13**	**9**

Sampling voyage Kaohsiung to Hamburg (Fig. 3, Tab. 4)
The highest number of zooplankton taxa (28) and the highest number of individuals (approximately 18,000 individuals/100 l) were found on day one. At the end of this 12 day sampling programme two taxa and fewer than 50 individuals were caught in the ballast water. During the initial part of the voyage, the number of individuals was drastically reduced from approximately 18,000 individuals/100 l to 6,000 individuals/100 l on day two. This trend continued to a lesser degree until the end of the voyage. The number of taxa fluctuated between 28 and 25 up to day five, then decreased to seven taxa after an additional four days. After sampling on day nine the ballast water was exchanged en-route in the middle of the Indian Ocean by emptying and refilling the tank. Afterwards the number of taxa (22) was higher than before the exchange (seven taxa) but in contrast the number of specimens showed a continuously decreasing trend. After the mid-ocean exchange of the ballast water the number of taxa decreased in a similar manner to that observed before the exchange (Fig. 3, Tab. 4).

Sampling voyage Odessa – Constanta – Varna – Odessa (Fig. 4, Tab. 5)
The survival rates of zooplankton taxa over the duration of the voyage in the Black Sea are shown in Fig. 4. The number of taxa and individuals decreased over time. The rate of decrease of organisms was highest between the first and last two samples. In the middle of the voyage a slight increase from approximately 1,500 to 1,700 individuals/100 l was observed. By the end of this voyage, fewer than 250 individuals/100 l were caught. On the second day, three additional taxa were found (in total 10 taxa) that were not observed on day

one. The number of taxa decreased continuously from the second day to the end of the voyage. In the last sample only one taxon was found (Fig. 4, Tab. 5).

Tab 4: Species sampled from the ballast water during the voyage Kaohsiung to Hamburg according to their daily occurrence in the samples. The first samples were taken on day three of the voyage. A mid-ocean exchange of the ballast water was undertaken after sampling on day 10.

	Duration (days)																							
Taxon	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Foraminifera	x	x	x	x	x	x	x	x	x	x	x													
Hydrozoa									x	x														
Mollusca																								
Gastropoda, larvae, indet.			x		x				x	x														
Bivalvia, larvae, indet.	x	x	x	x	x	x		x	x						x									
Crustacea																								
Copepoda																								
Acartia spinicauda	x	x	x	x	x		x		x				x				x							
Acrocalanus longicornis	x	x	x	x	x				x	x														
Calanoida, adult, indet.	x		x	x					x	x		x												
Calanoida, larvae, indet.	x	x	x	x	x	x	x	x	x	x	x			x	x				x	x				x
Corycaeus sp.		x	x	x																				
Hapacticoida, indet.	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Oithona attenuata	x	x	x	x		x	x		x															
Oithona brevicornois	x	x	x	x	x																			
Oithona nana		x	x																					
Oithona oculata	x	x	x	x	x	x	x	x	x	x	x							x			x	x	x	
Oithona simplex	x	x	x	x	x	x	x	x	x				x			x								
Oithona sp.	x	x	x	x					x															
Oncaea clevi	x	x	x	x	x				x	x														
Paracalanus parvus	x	x	x																					
Paracalanus sp.1	x	x	x	x	x	x			x	x	x													
Paracalanus sp.2	x	x	x	x	x																			
Pontelidae	x	x	x	x	x	x	x		x															
Temora sp.	x	x	x	x					x	x														
Cladocera																								
Evadne sp.	x	x																						
Penilia avirostris	x	x	x	x																				
Cirripedia																								
Balanus sp. nauplii	x	x	x	x	x	x	x		x	x	x													
Decapoda, larvae, indet.	x	x	x	x					x															
Isopoda, indet	x	x																						
Amphipoda	x	x	x	x																				
Caprellidae	x	x																						
Conchostraca, indet.									x	x	x				x									
Decapoda, larvae, indet.	x	x	x	x			x	x	x	x														
Polychaeta, larvae, indet.	x	x	x	x	x	x	x		x	x	x													
Chaetognatha																								
Sagitta sp.	x	x	x	x	x																			
Tunicata	x	x	x																					
Total number of taxa found	**29**	**30**	**29**	**25**	**17**	**11**	**11**	**7**	**22**	**15**	**8**	**1**	**3**	**2**	**4**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Tab 5: Species sampled from the ballast water during the voyage from Odessa to Constanta and Varna and back to Odessa according to their daily occurrence in the samples.

	Duration (days)			
Taxon	0	1	2	3
Mollusca				
Gastropod, larvae, indet.	x	x		
Mytilaster lineatus, larvae	x			
Mya areniaria, larvae	x	x	x	
Crustacea				
Copepoda				
Acartia clausi, nauplii		x	x	
Harpacticoida, indet.	x	x	x	
Oithona similis, nauplii		x		
Synchaeta cf. *baltica*		x		
Cirripedia				
Balanus improvisus, larvae	x	x	x	x
Polychaeta				
Polydora ciliata, larvae	x	x	x	
Spio fillicornis		x		
Neanthes (*Nereis*) *succinea*	x	x		
Total number of taxa found	**7**	**10**	**5**	**1**

During all the ocean-going sampling trials the numbers of zooplankton taxa and individuals decreased over time. In three of the sampling trials (voyages to Norway, Germany and Black Sea) the number of taxa fluctuated at the beginning of the voyage, but showed sharp decreases after no more than five days. Similarly, the number of individuals fluctuated at the beginning of the voyages to Portugal, Norway and the Black Sea, with a steady decrease up to the end of these voyages. On all voyages a drastic decrease of the zooplankton occurred within the first three days when the number of organisms sampled was less than half of the first day. The maximum decrease in individuals was observed during the trip from Kaohsiung to Germany when numbers decreased from approximately 18,000 to approximately 6,000 individuals/100 l between the first and second sample.

Taxa and individual numbers decreased at broadly comparable rates. Nevertheless, apart from the 10 day period on the voyage to Lisbon, the other studies showed that at the end of the voyages some taxa were still alive, but in much lower numbers than when the study commenced.

Discussion

These results confirm previous ship sampling trials (Carlton (unpublished data), Rigby & Hallegraeff 1993, 1994, Fukuyo et al. 1995). All investigations showed a rapid decline in plankton concentration during the initial days of the voyage. As with Carlton (1985), Williams et al. (1988) and Gollasch (1996) the results from all voyages showed that the diversity and number of specimens decreased with increasing duration in the ballast tank. Williams et al. (1988) documented a predominant decrease of diversity in ballast water during the first 3 weeks. Results of this study showed that even after a shorter period of time no living organisms were found.

If the decreased density of specimens and species in the zooplankton samples during the voyages was due to a high mortality rate or due to migration of specimens from the water column in the ballast tank towards hiding areas near supporting frames is not clear. However, in general, it is assumed that the decreasing numbers of species caught towards the end of the voyages indicate low survival rates potentially caused by (a) the absence of light in the ballast tanks, (b) negative impacts of the changing environmental conditions during voyages through different climatic zones, (c) “sloshing” of the water in the tank caused by the rolling of the ship could also have had an adverse effect on delicate plankton organisms (Gollasch et al. 2000 a,b+c) and (d) the limited food supply. Furthermore, (e) the ships pumps used to pump the ballast water into the tanks may have damaged fragile and gelatinous zooplankton organisms.

Other ballast water studies have shown that living organisms were found in ballast water that was left in the ballast tanks for weeks and/or months (Medcof 1975, Howarth 1981, Carlton 1985, 1987, Williams et al. 1988, Pollard & Hutchings 1990, Jones 1991, Hallegraeff & Bolch 1991, 1992, Smith & Kerr 1992, Rigby & Hallegraeff 1993, 1994, Smith et al. 1993, Kerr 1994, Subba Rao et al. 1994, Smith 1995, Gollasch et al. 1998, Lenz et al. 1999). Even after 116 days in a ballast tank living specimens of the amphipod *Corophium acherusicum* were found during the German shipping study (Gollasch 1996). In addition to the “long-term” survival of some organisms in ballast tanks other species form resting stages or cysts enabling survival during periods of unfavourable conditions for up to several years. A surprising observation not previously documented was that a zooplankton species had considerably increased in concentration during a voyage from Singapore to Germany. Initially, 11 specimens of *Tisbe graciloides*/100 l were collected; after 15 days 1040 specimens were counted (Lenz et al. 1999). This increase demonstrates that conditions inside ballast tanks can support the development and reproduction of some taxa contained within the tank. It is suggested that factors related to this unique observation were: low competition through decreasing diversity, absence of natural predators and unlimited food supply. This new dimension of species transportation in ships shows that ballast tanks may act as incubators under special conditions and further emphasises the risk of species transport with this vector.

Conclusions

During all four sampling trials, diversity and abundance of zooplankton decreased over time. Individual numbers and taxa decreased in a comparable manner. Nevertheless, investigations showed that at the end of most trips, some species were still alive at low densities. Other species may reproduce in ballast water tanks or form resting stages. It is not therefore recommended to keep the ballast water in the tanks as long as possible in the hope that specimens will not survive, in order to address the problem of unintentional species introductions by ballast water discharges.

The treatment of ballast water is necessary in light of increasing risks involved with ballast water releases. The presence of human disease agents in ballast water e.g. *Vibrio cholerae*, the cholera bacteria, emphasises the need for ballast water treatment (Gollasch & Leppäkoski 1999). Ignoring the problems related to unintentional species introductions has been termed “ecological roulette” (Carlton & Geller 1993, Hedgpeth 1993, Locke et al. 1993). In addition, ship sampling studies have demonstrated that each single vessel releasing ballast water from abroad has the capacity to introduce unwanted nonnative species to new habitats. Efforts to prevent or minimise introductions should be a matter of high priority.

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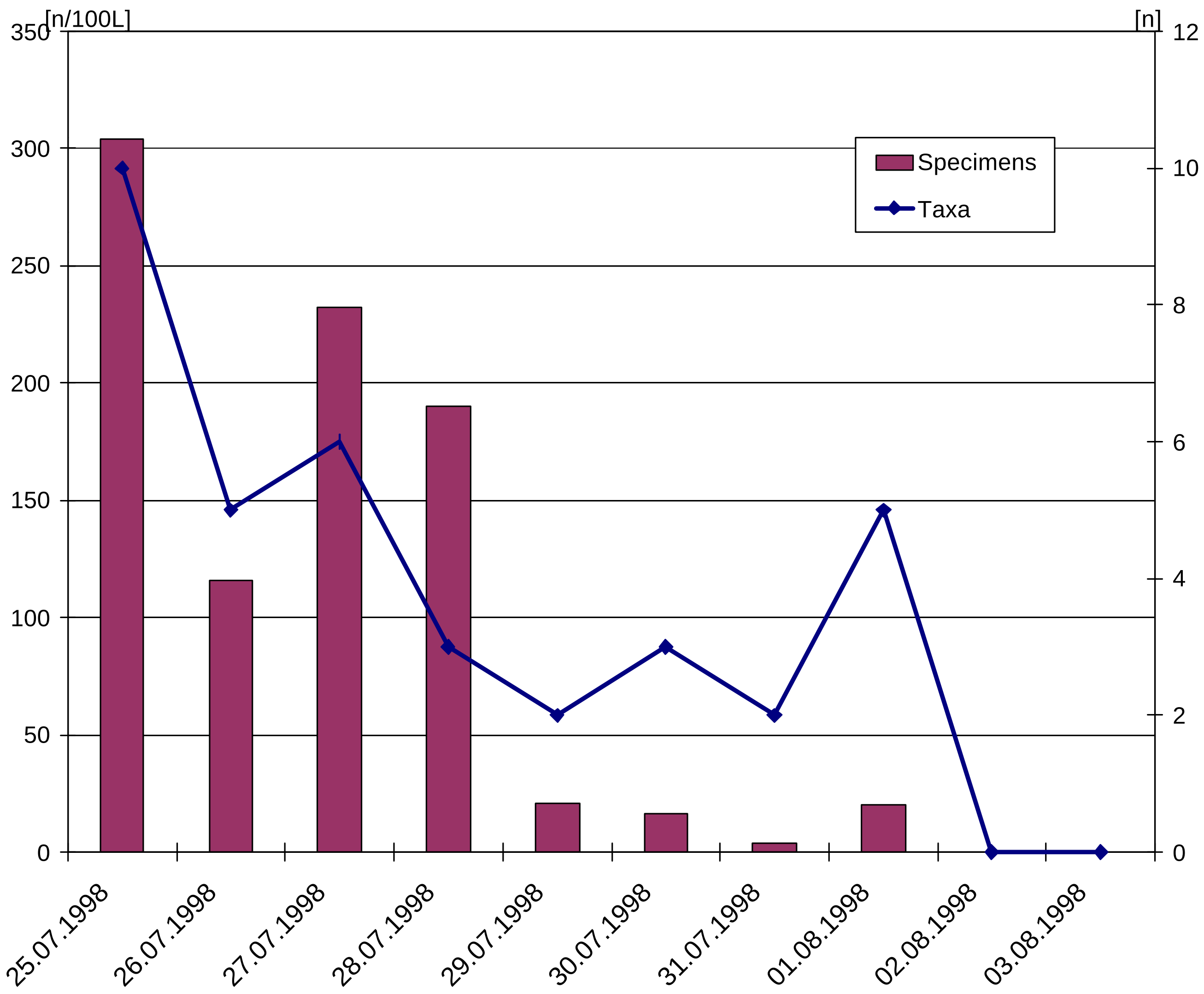

Fig.: 1 Number of zooplankton taxa and individuals in the ballast water during the voyage from St. Petersburg to Lisbon. Origin of the ballast water investigated in the aft peak tank: Northern Baltic Sea. All samples were taken using a cone-shaped zooplankton net (mesh size 55 µm) via an opened manhole.

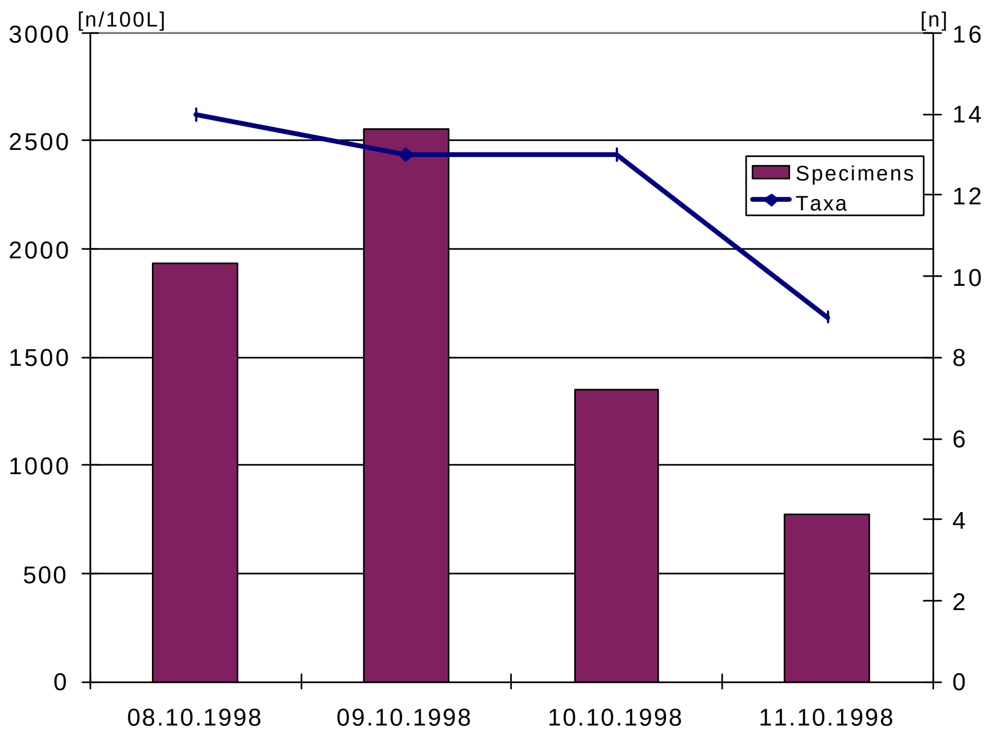

Fig.: 2 Number of zooplankton taxa and individuals in the ballast water during the ships voyage from Cork (Ireland) to Sture (Norway). Origin of the ballast water investigated: Cork. All samples were taken from wing tank port side operating a cone shaped plankton net (mesh size: 55 µm) via an opened manhole.

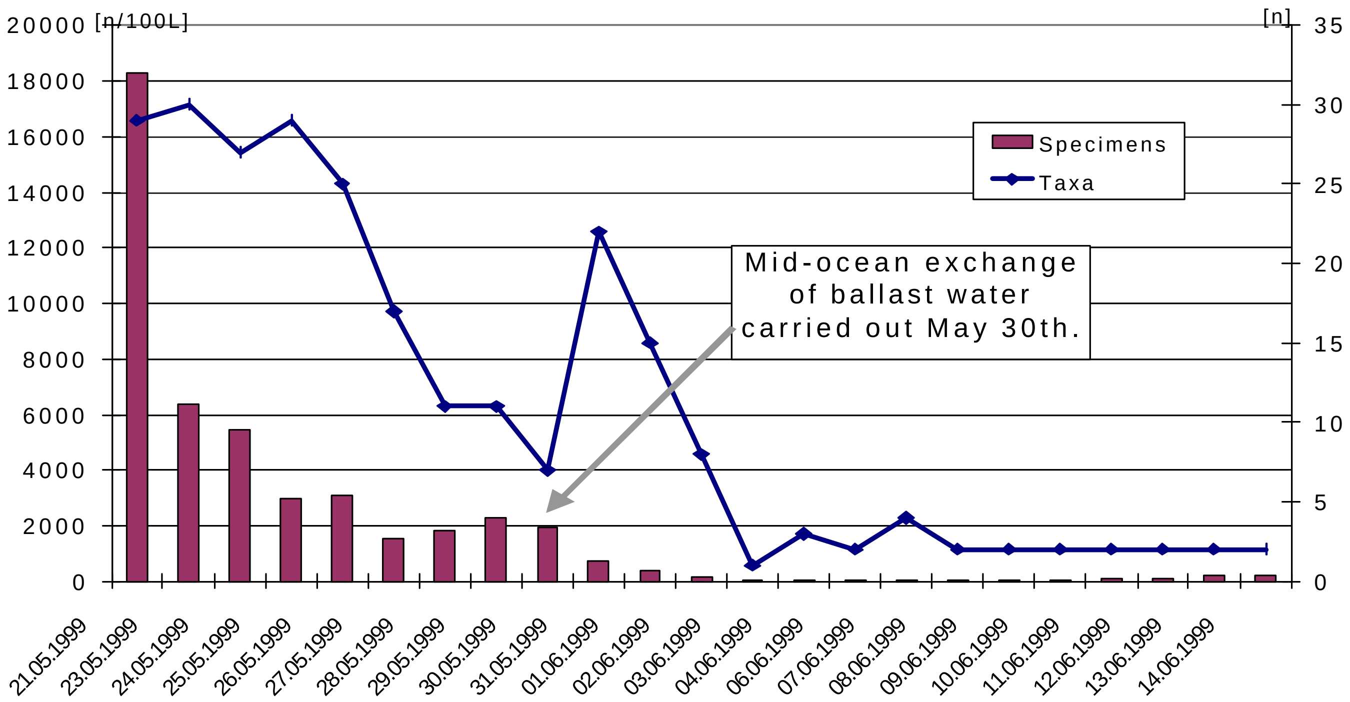

Fig.: 3 Number of zooplankton taxa and individuals from the ballast water of the portside side tank during the ships voyage from Kaohsiung to Hamburg. Origin of the ballast water investigated: Hong Kong. After sampling on the 30th of May a mid-ocean exchange of the ballast water was undertaken. All samples were taken using plankton net with a mesh size of 55 µm.

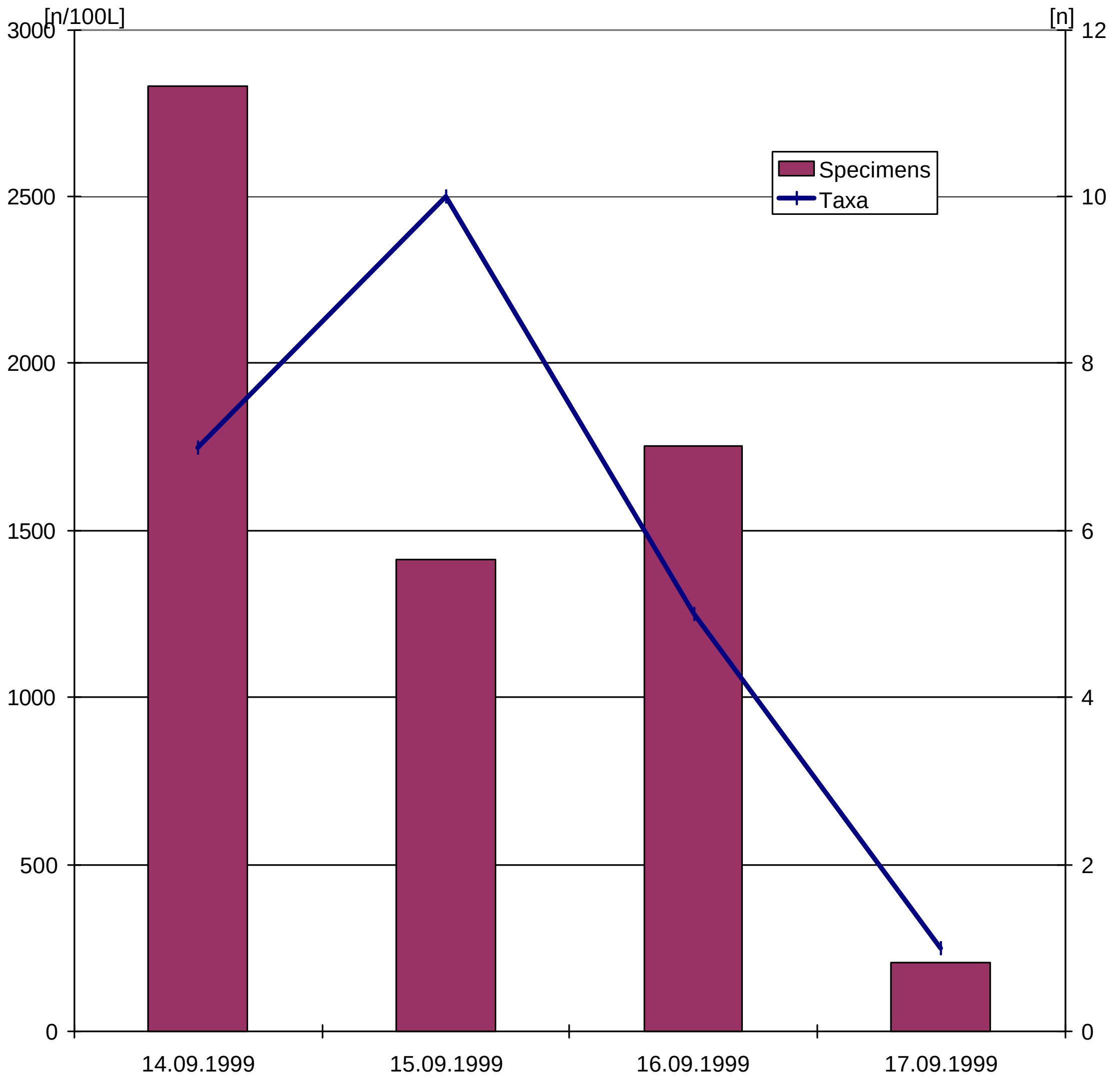

Fig.: 4 Number of zooplankton taxa and individuals in the ballast water of the engine room ballast tank during the ships voyage from Odessa to Constanta and Varna and back to Odessa. Origin of the ballast water investigated: Odessa. All samples were taken using a cone shaped plankton net with a mesh size of 55 µm.

CURRICULUM VITAE

Capt. Christian Bahlke, M.Sc. (Nautical Studies)

Born: 6th June 1957 in Schwerin

Start of seafaring as cadet in 1974; further career until 1994 with Master Mariners certificate ocean going in 1985 and diploma 'Dipl.- Wirtschaftsingenieur für Seeverkehr. Employee of Sloman Neptun Shipping Company with positions as AB, nautical Officer, Chief Officer and finally Master.

Training for labour safety, various safety courses of instructions, designated person for transportation of dangerous goods.

From 1994 to 1995 full time professional training with final certificate "Expert for the International Marine Environmental Protection" with the Bremen Hafenfachschule (Professional Training Institute); in addition in 1995 certified participant of the training course "Shipment of Dangerous Cargo" with the Department of Nautical Studies, Bremen Polytechnic University.

From 1996 to 1997 employment with Bremen University of Applied Sciences / GAUSS. Scientific work for the Umweltbundesamt, Berlin (German Environmental Protection Agency), in the field of "Transportation of Dangerous Goods on board roro-ferries".

1997 to 1999 employee with Van Ommeren Bremen, with focal points on STCW 95, ISM Code implementation and crewing.

Since September 1999 projectmanager with GAUSS in the fields of environmentally friendly shipping and transport of dangerous goods.

Abstract

Christian Balke, GAUSS, GE

"Research into the efficiency and practicability of different technical methods to treat ballast water with the aim to develop an optimised process engineering."

The introduction of foreign species via the transfer and release of ballast water poses a high risk of destruction to the local biodiversity, aqua farming, tourism and facilities in harbours and at sea. The development of ever bigger and faster vessels, carrying vast amounts of ballast water requires adequate means to assess and solve this problem. For the time being neither proved technical approaches nor common accepted regulations are available

In order to evaluate the efficiency and advantages / disadvantages of a variety of ballast water treatment a large scale comparable research is necessary. The first step of this project is therefore the assessment of the applicability of existing ballast water treatment methods. The performance of different methods has to be demonstrated on test runs. In addition, methods which have not been tested for ballast water application (but were used with good results in similar cases on-shore and off-shore (transfer of technology)) and subsequently no experience on shipboard use is available, will be considered. The scientific biological evaluation and comparative research into untreated and treated ballast water will then lead to conclusions on the efficiency of the different approaches. Based on the know how of positive aspects of the different ways to treat ballast water the combination of capable methods and further investigation might result in improved treatment methods.

As the shore-based research differs from shipboard application it is further planned to install the most promising methods and equipment on board merchant vessels. This second step shall prove the reliability on board and shall cover the varying conditions and implications due to different trades worldwide. At the end of the project the prototype of a plant will have been developed which is the optimised combination of available techniques.

Ballast water project released in Bremen

Development and Construction of an Efficient and Marketable Ballast Water Treatment Plant

Background

The transfer and introduction of foreign species into native coastal waters by ballast water is nowadays probably one of the biggest threat to the environment due to shipping. However, presently the focus of public attention lies mainly on the pollution of coastal regions by an outflow of oil and the perception still disregards harmful effects on the local biodiversity and imminent threats to maritime resources, for fishing and aqua farming caused by foreign species. Although the impact of e.g. an oil spill caused by a large tanker accident might be disastrous for coastal waters, it will be most probably cured within a certain period of time and the origin community of life will finally recover and be re-established.

The situation with ballast water is different. On first sight it might not even be noticed that foreign species are released into the maritime environment, but if these immigrants manage to survive, from a certain "point of no return" it will not be possible anymore to prevent the spread and subsequently large ecological and also economical damage is pending - which was actually experienced in many cases already.

The harmful effects of the introduction of foreign species are known since long ago, however investigations are conducted only since a few decades. The increasing attention drawn to this problems is nowadays resulting from the fact that constantly growing shipping with ever bigger vessels carrying corresponding amounts of ballast water including foreign species pose an increasing risk to the maritime environment. According to insights, in addition the higher speed of modern vessels improve the survival rate of these stowaways due to abbreviated crossing of climate zones.

Worldwide operating organisations like UNEP (Rio Declaration in 1992) and the IMO are therefore calling for action and consequently research institutes and the maritime industry are putting increasing effort to tackle this problem.

Scope of the R&D Project

Initiated by GAUSS Institute for Environmental Protection and Safety in Shipping, sponsored by the Federal State of Bremen, Senator for Construction and Environment, a ballast water project was commenced on 1st September 2001. The project-partners are

- Shipyard MWB Motorenwerke Bremerhaven AG
- Kraeft GmbH, Bremerhaven
- GAUSS Institute for Environmental Protection and Safety in Shipping, Bremen

in cooperation with Alfred-Wegener-Institut for Marine and Polar Research in Bremerhaven and GoConsult in Hamburg.

The project is designed to be carried out in three phases, comprising 36 month in total. The first phase takes 10 month and is supposed to provide theoretical background on the subject. The tasks to be dealt with are inter alia the legal framework of different regimes, biological circumstances of organisms in ballast water in connection with the identification of model groups and the requirements arising from the situation on board different types of vessels. Most import in the first phase will be the assessment of the different ballast water treatment approaches, which might be promising to address the problem. Some methods will be called in which are known to be tested on board already, but also alternatives from shore-based application might be considered. At the end of the first phase the results should indicate methods with the capability to be combined in order to find a solution with the highest potential for successful performance.

Based on the definition in phase one, during the second phase of 14 months test runs will be carried out to evaluate the assets and drawbacks to approach the problem. The simultaneous assessment of methods using varying ballast waters from ships sailing worldwide should offer opportunities to find effective and reliable solutions for practical use.

Finally, in phase 3 these test plants are to be converted into one or two prototypes which will be evaluated and optimised under real conditions. 12 month for installation and testing on board are provided to assess the actual performance. During this period especially the varying and sometimes demanding conditions at sea should be addressed in order to develop an efficient and marketable solution to treat ballast water.

Invitation to participate

The point of time for the conference "Ballast water, Waste Water and Sewage Treatment on Ships and in Ports" in Bremerhaven could not be better in coincidence with the start of the project. Thanks to the organizer of the conference the scope of the ballast water project could be presented in order to provide and offer an open forum on questions in connection with ballast water handling and treatment opportunities. The problem is quite complex and all efforts should be combined to find a solution for this pending problem. In this sense the participants on the conference - no matter whether they are suppliers, ship-managers or other representatives - are invited to share approaches to deal with this challenge, express experiences already gained and, on a later stage, benefit from the results attained in common.

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Germany	

Development and Construction of an Efficient and Marketable Ballast Water Treatment Plant

- Sponsored by : Senator für Bau und Umwelt, Bremen
- Timeframe : September 2001 – August 2004 (?)
- Projectpartner :
    - MWB Motorenwerke Bremerhaven AG
    - Kraeft GmbH
    - GAUSS g. mbH (Capt. Chr. Bahlke)

Transfer and Introduction of Non-Indigenous Species by Shipping

- Foreign species in cargoholds
- Foreign species on shipshull, seachests etc.
- Foreign species in ballast water tanks
- Foreign species in the sediment

Approaches on the Risks arising from Foreign Species in Ballast Water

- Laissez faire
- No exchangeable ballast (water)
- Delivery on shore
- Ballast water exchange at sea
- Ballast water treatment at sea

Development and Construction of an Efficient and Marketable Ballast Water Treatment Plant

- 1. Phase:

  Framework and feasability study

- 2. Phase:

  Research and experiments on shore

- 3. Phase:

  Prototyping and service on board

Phase 1: Framework and Feasability Study

- Legal framework
- Biological background
- Biological test-parameter
- Identification of special areas
- Damage due to spread of foreign species

Phase 1: Framework and Feasability Study

- Special requirements on ships (old / new)
- Technical properties of components
- Selection on methods / combinations
- Market- and economical potential
- Report Phase 1, Definition of phase 2

Phase 2: Setup and Experiments on Shore

- Procurement of components
- Preparation for testing
- Testing with native and foreign water
- Selection on combination of methods
- Report Phase 2, Definition of phase 3

Phase 3: Prototyping and Service on Board

- Concept and construction of prototype
- Choice on shipowners and ships
- Installation and testing on board
- Adjustment and optimization
- Report, evaluation, presentation

Invitation to Participate

- Shipowners and -managers
- Supplier of components
- Research institutions
- Other bodies

BW - Treatment

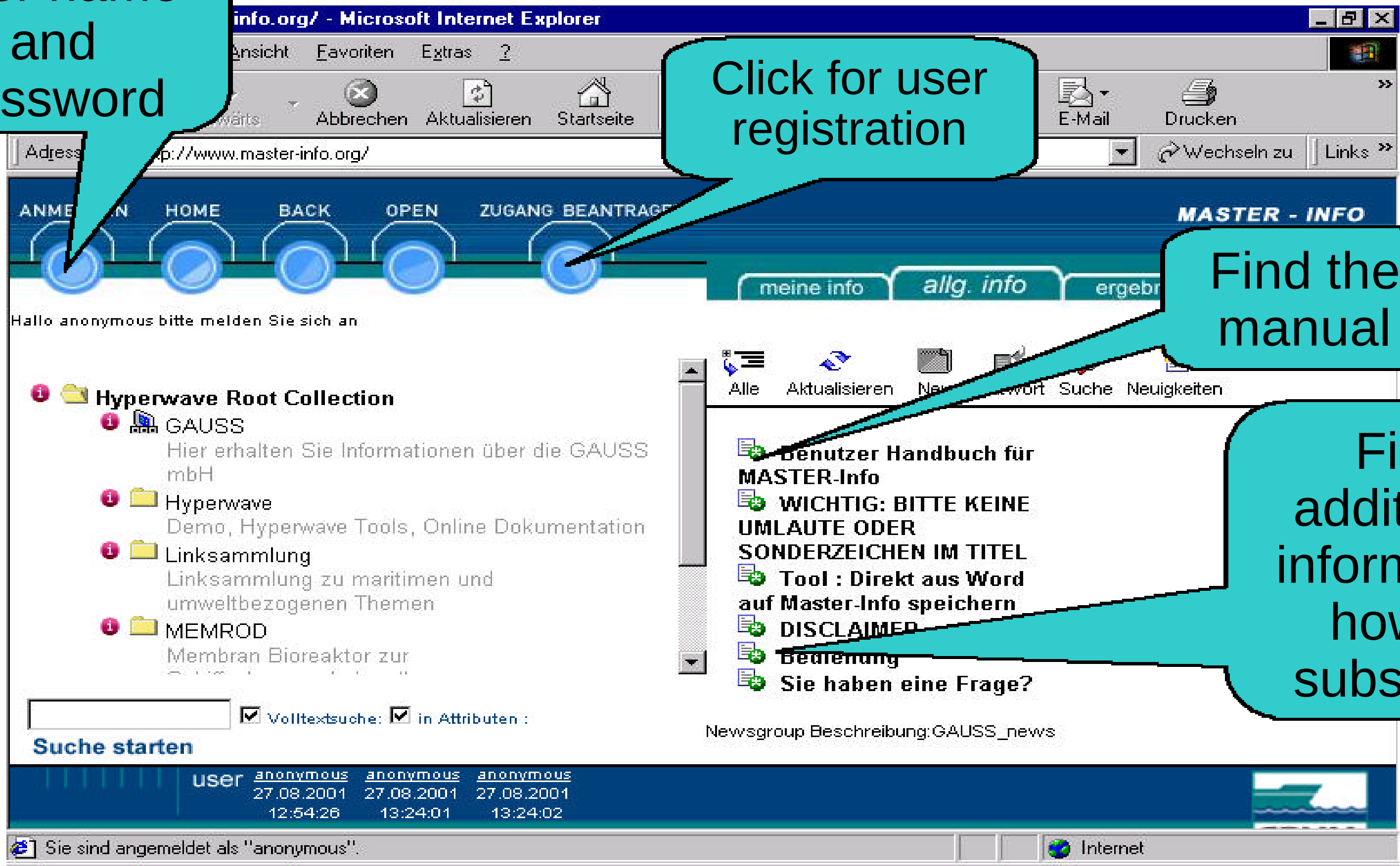
www.master-info.org
Ballast Water Online Information

Log in with user name and password

Click for user registration

Find the manual

Find additional information how to subscribe



Coordinates of Projectadministration

- GAUSS g. mbH

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- www.gauss.org / www.master-info.org

CURRICULUM VITAE

Dr. Rainer Fuchs
Senior Manager
Environment Chemistry
Peroxygen Chemicals

Degussa AG
Rodenbacher Chaussee 4
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Tel. 06181-59-3892

Dr. Rainer Fuchs
has **studied organic synthetic chemistry at Würzburg**, Germany with Prof. Waldemar **Adam**.
In 1990, he startet his work as a chemist at **Degussa AG**.
For three years, he worked in a research group on **peroxygen compounds and formulations.**
Then he developed **environmentally friendly treatments for waste air, wastewater and polluted soil**. He specialized in the **development of new peroxygen formulations and environmentally friendly water treatment processes**.

He has now over 13 years of experience in the field of **peroxygen chemistry** and more than 8 years in the development of **environmentally friendly, new processes**.

Abstract

Dr. Rainer Fuchs
Senior Manager
Environment Chemistry
Peroxygen Chemicals

Degussa AG
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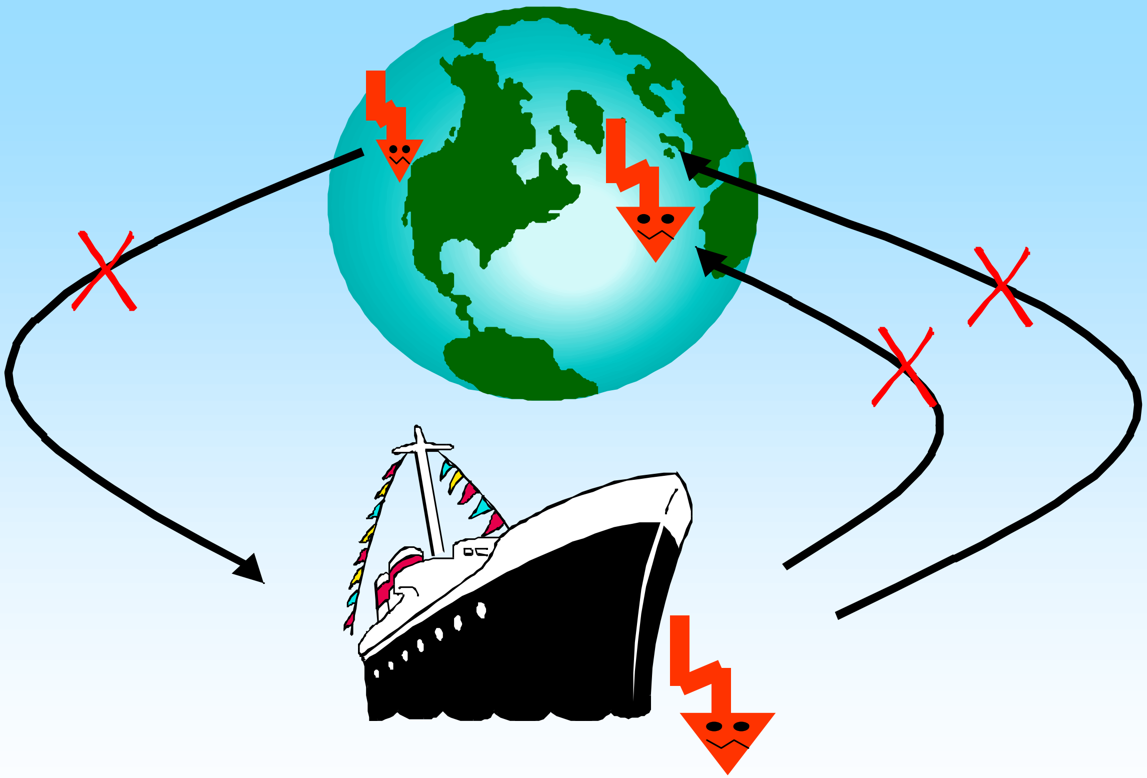
Tel. 06181-59-3892

"Environmentally Sound and Effective Ballast Water Treatment by Peraclean Ocean - Results of Practical Tests - "

Degussa developed a new and environmentally friendly treatment option for ballast water: The liquid, proprietary peroxygen formulation Peraclean® Ocean is dosed into the stream during the uptake of the ballast water. The formulation effectively kills the organisms and pathogens in the water within minutes to hours. Until the release of the ballast water Peraclean® Ocean degrades to environmentally friendly components without any toxic residues.
In order to demonstrate the the formulation`s performance under realistic circumstances, two large scale field tests were conducted. The results are presented within the scope of this paper.

Peraclean® Ocean - an Environmentally Sound Treatment Option for Ballast Water

Global Transfer of Ballast Water



Approximately 12 billion tons of ballast water are transported every year

IMO: Separation + Biocidal Treatment: a future?

**"It now seems likely
that any new ballast water treatment system
will involve a combination of technologies,
for example
primary filtration or physical separation
followed
by a secondary biocidal treatment"**

IMO NEWS, 2, 2001

Funding of a Chemical Treatment Project

„Process for the removal of organisms from different waters“

Degussa AG

50%

German Federal Ministry of Education and Research [02/WA9912]

50%

Peraclean® Ocean

- **Degrades to acetic acid, oxygen and water**
- **Degradation products are readily biodegradable**

$$CH_3COOOH + H_2O \rightarrow H_2O_2 + CH_3COOH$$

Acetic acid

$$2\,H_2O_2 \rightarrow O_2 + 2\,H_2O$$

Oxygen + Water

- **Is not persistant and does not accumulate: No toxic residues**

Peraclean® Ocean

Kills:

- **bacteria**
- **yeasts**
- **viruses**
- **molds**
- **spores**
- **algae**
- **protozoa**

- **<u>Higher organisms in ballast water</u>, e.g.**
  - **zooplankton**
  - **phythoplankton**
  - **larval stages**
  - **fish eggs**

Peraclean® Ocean

Is active at: **high concentrations of sediment and / or organic matter**

pH 5 - 9

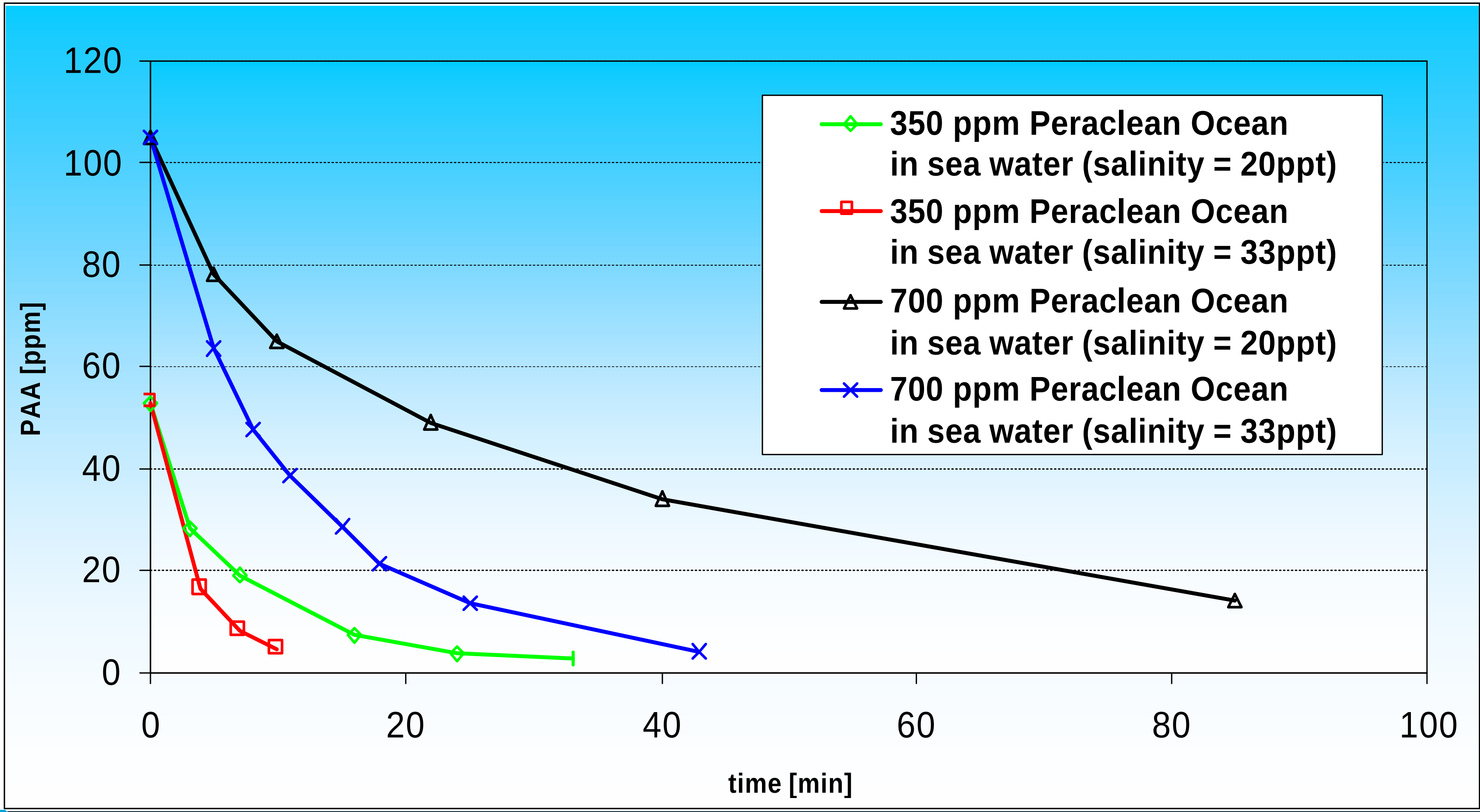
-5°C to more than 40°C

Possible Ballast Water Treatment Scenarios

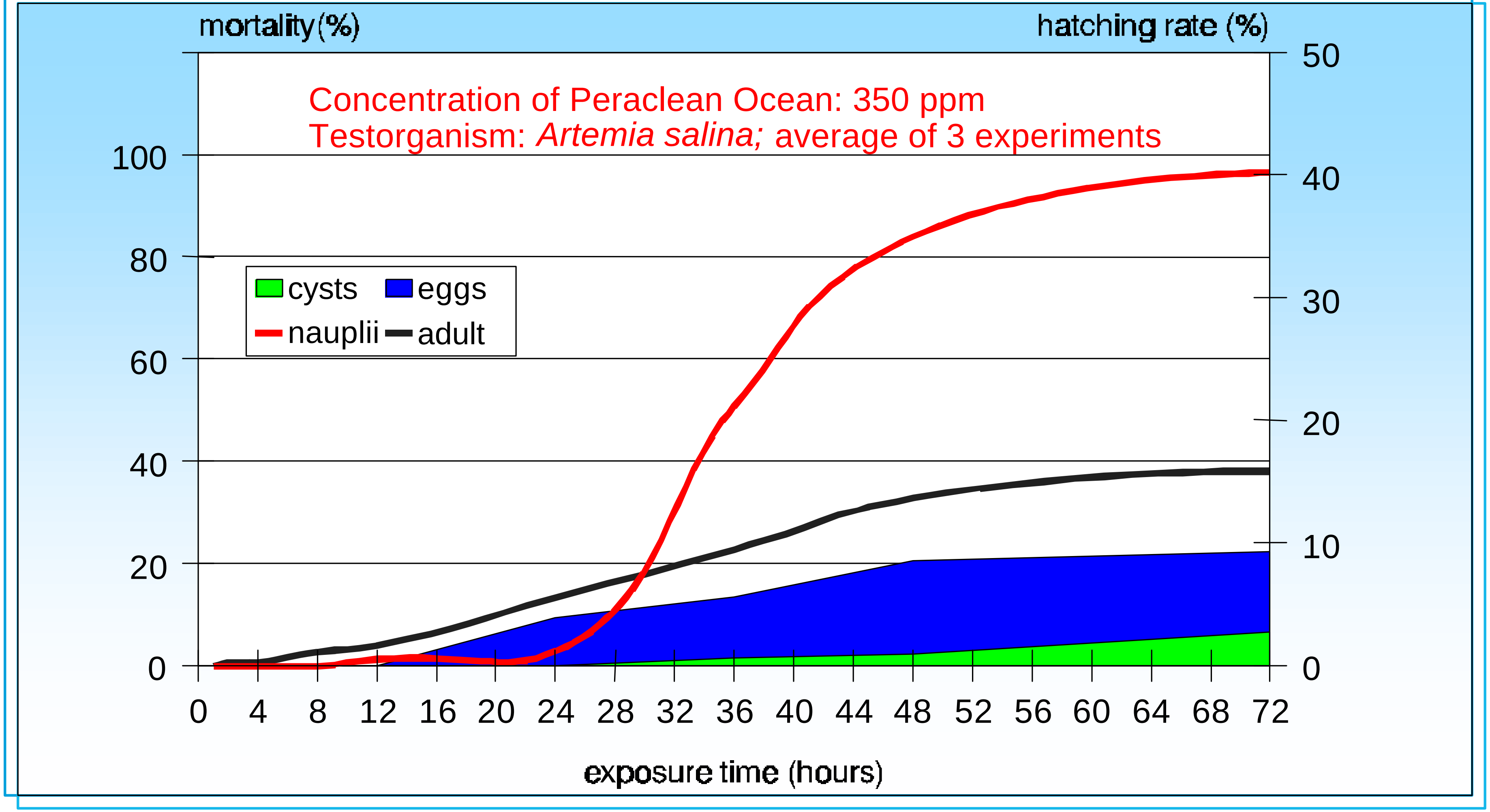
On ships:
- **stand alone treatment with Peraclean® Ocean**
- **separation + Peraclean® Ocean**
- **emergency treatment**

Land based:
- **treatment plants at harbour sites**

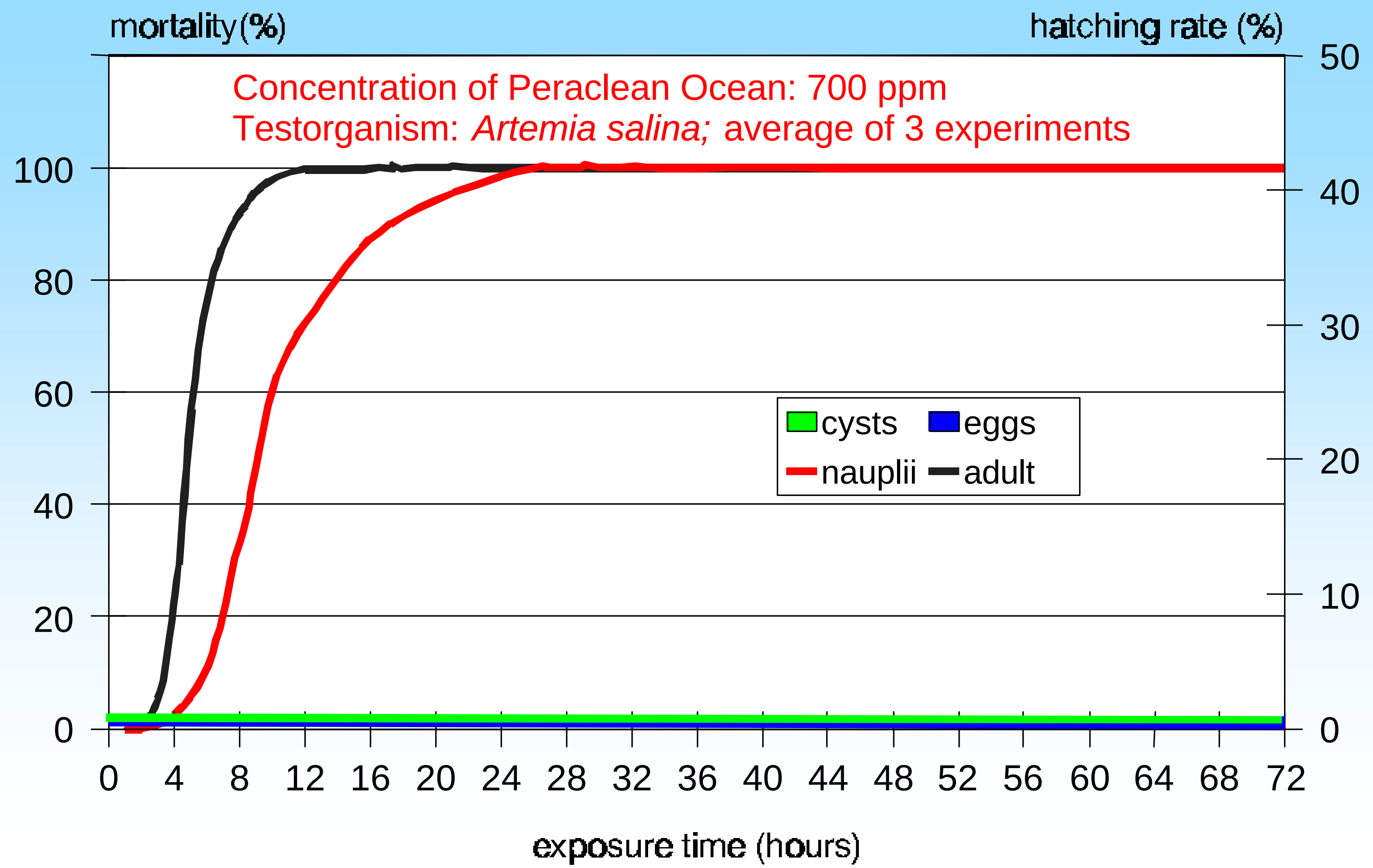
Decomposition of Peraclean® Ocean in Sea Water



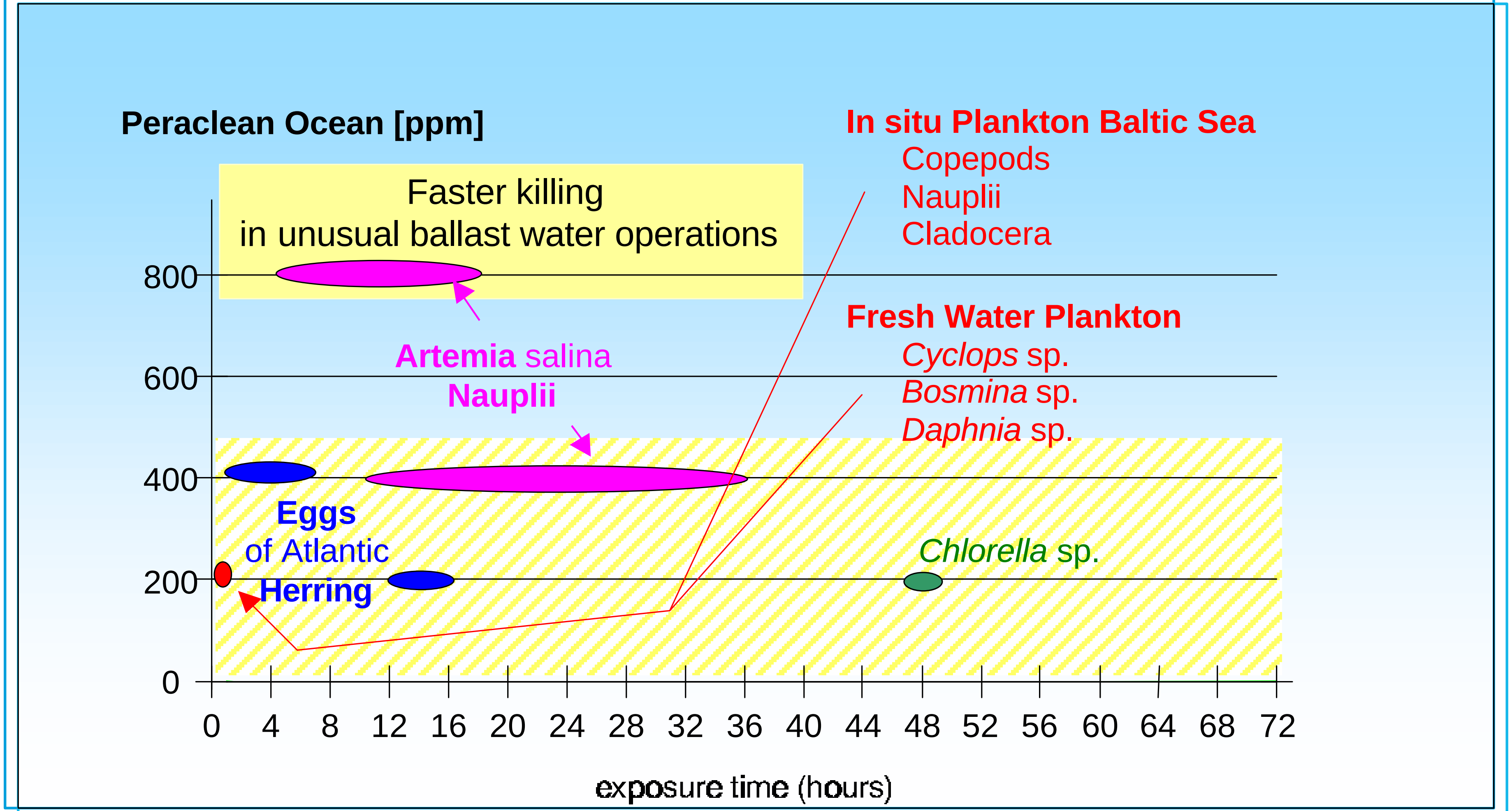
Stand Alone Treatment: ATS-Test
350 ppm Peraclean® Ocean



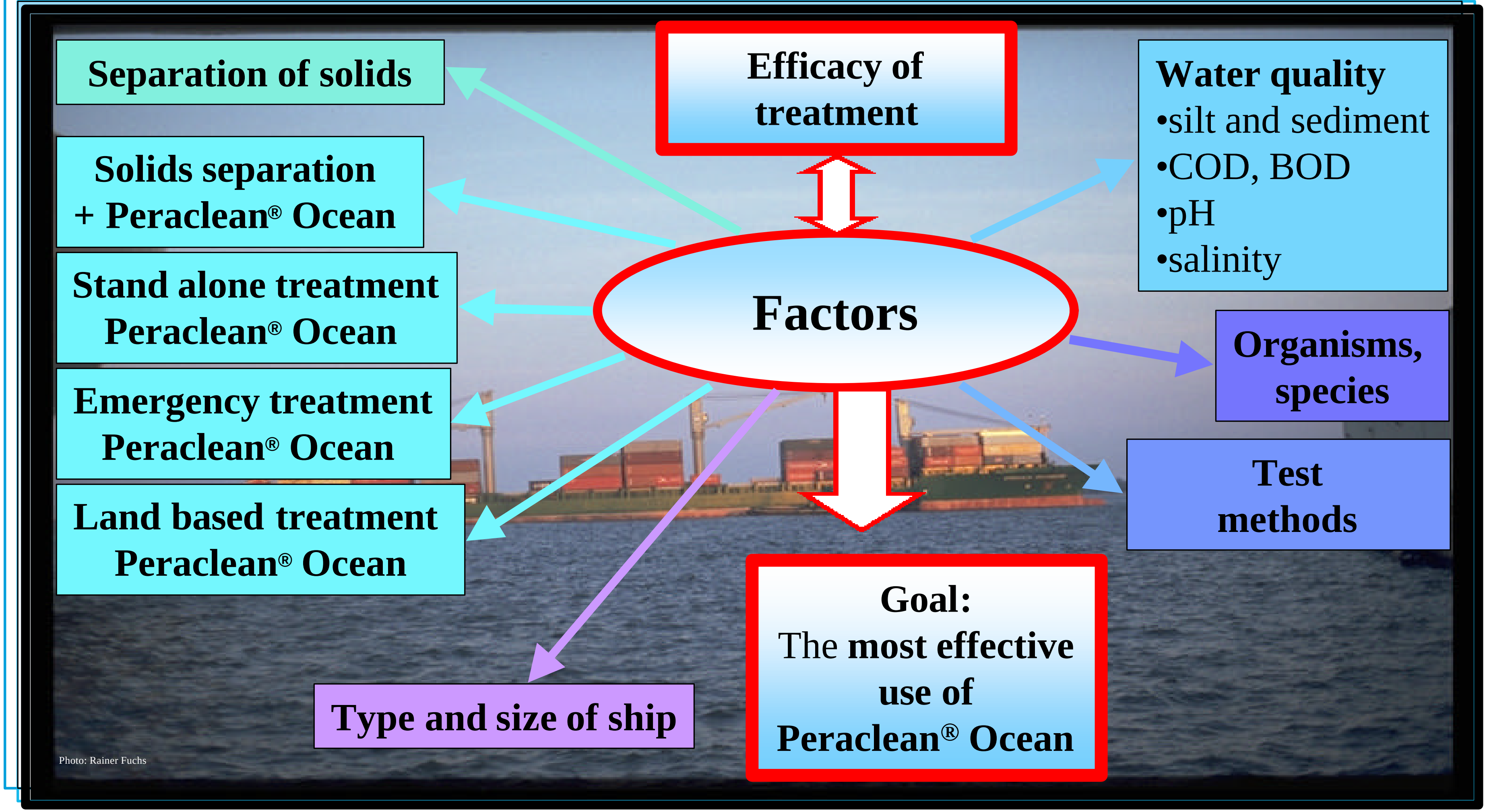
Stand Alone Treatment: ATS-Test
700 ppm Peraclean® Ocean



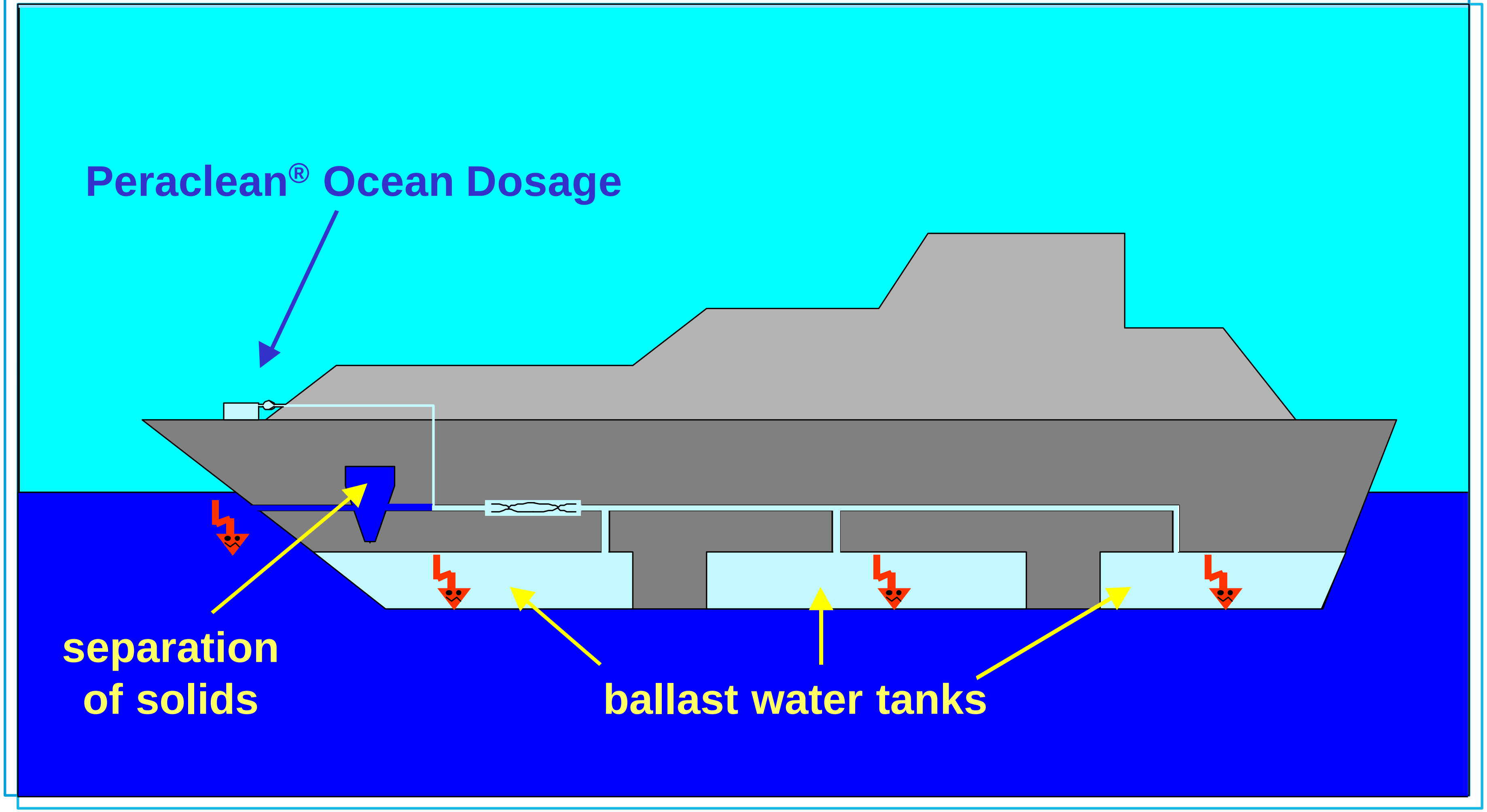
Stand Alone Treatment: Which Dosage is required ?



Practical Tests with Peraclean® Ocean



Scheme of the Ballast Water Treatment



Field trial with Peraclean® Ocean: USA

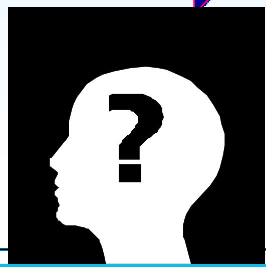
Organization of experimental setup: **Maritime Solutions Inc.**

June, July 2001:
dosage of 50-400 ppm
Peraclean® Ocean

necessary dosage for effective killing:100-200 ppm Peraclean® Ocean (stand alone!)

Preliminary results!

September / October 2001:
dosage
with separation



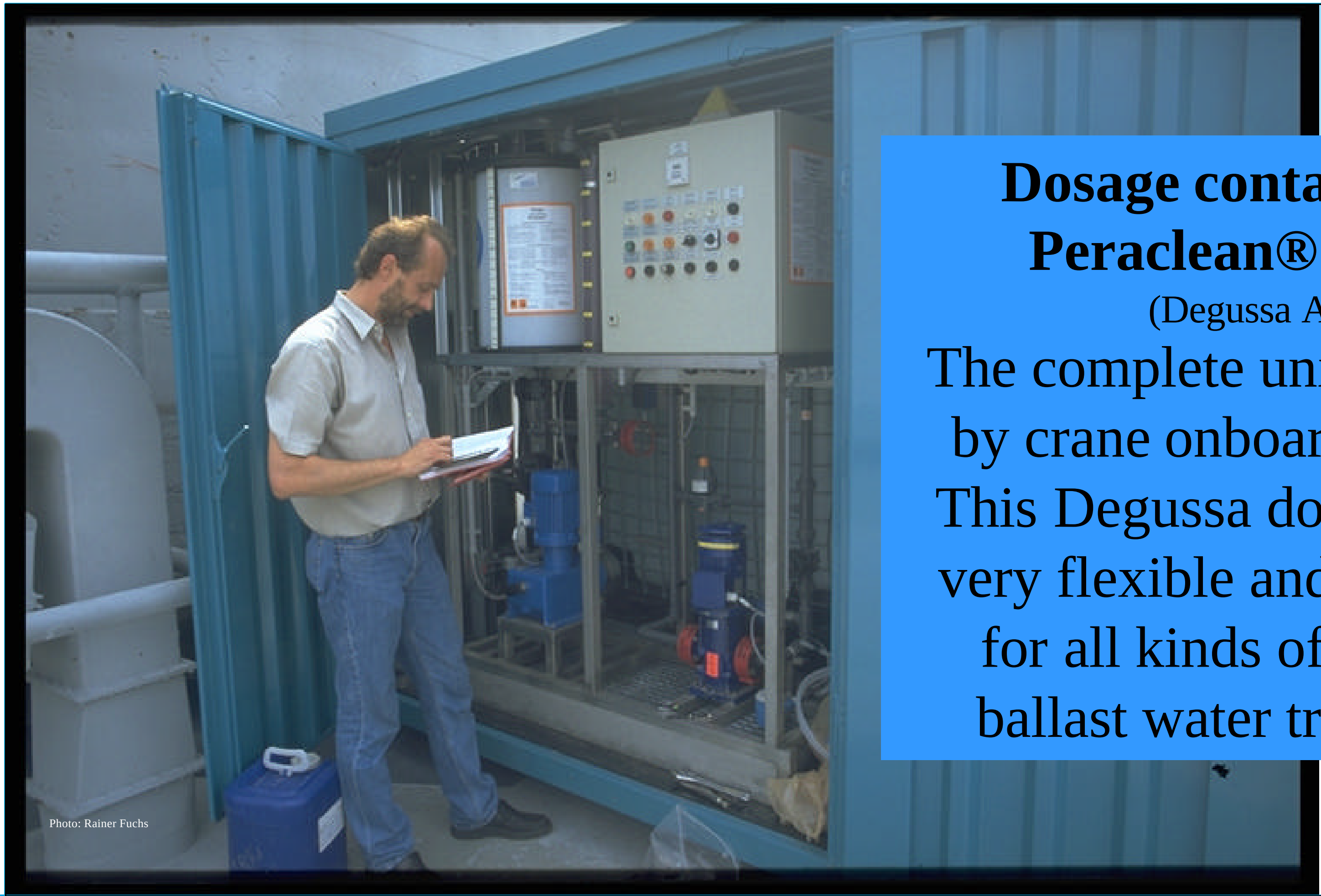
Lower dosage needed for effective killing?

The vessel „CAPE MAY“ in the port of Baltimore

Photo: Rainer Fuchs

- 10.000 t Ballast-water
- 30.000 t dead weight (DWT)

Peraclean® Ocean dosage onboard of „CAPE MAY“



Dosage container for Peraclean® Ocean
(Degussa AG)

The complete unit was lifted by crane onboard the ship. This Degussa dosage unit is very flexible and is suitable for all kinds of different ballast water treatments.

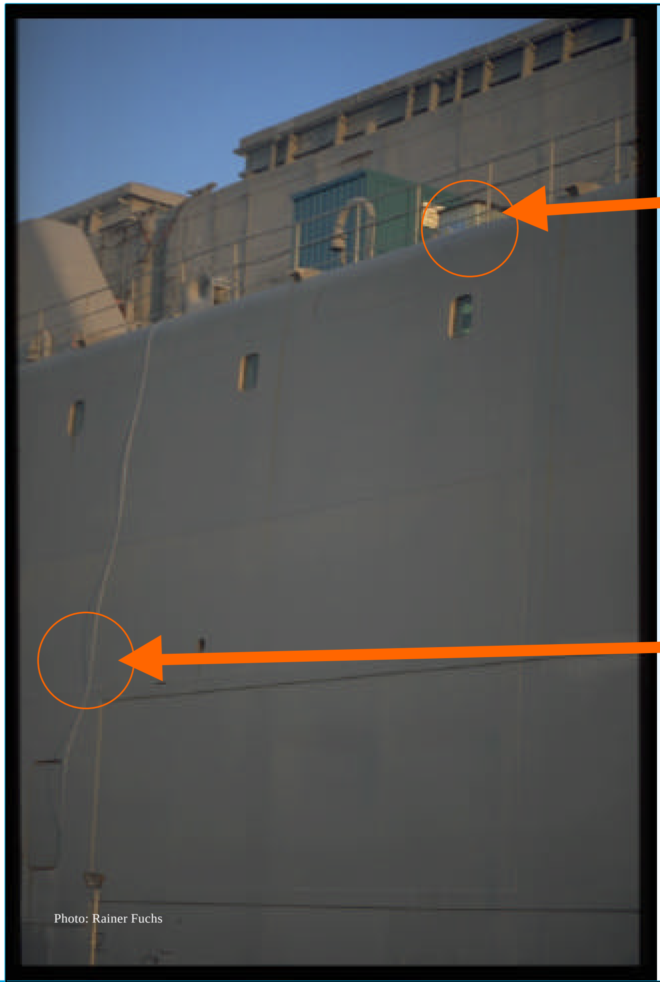
Peraclean® Ocean dosage onboard the „CAPE MAY“

Our field laboratory

enabled us to determine the exact **concentration of product** in the ballast water.

Also
the **decay of Peraclean® Ocean** in the actual ballast water could be measured.

Peraclean® Ocean dosage onboard „CAPE MAY“



Impressive:
Dosage of 2 t Peraclean® Ocean enables a complete treatment of the ship`s ballast water (10.000 t).

Thin:
1 cm internal diameter of the dosage line is in this case enough for a proper treatment

Field trial with Peraclean® Ocean: Germany

Organization of experimental setup:

Hamann Wassertechnik, Hamburg

August - October 2001:
Dosage of 50 - 500 ppm Peraclean® Ocean

- Efficacy of Peraclean® Ocean in brackish- and sea water
- Effective killing achieved with less than 200 ppm Peraclean® Ocean
- **Preliminary results!**
- Future tests with and without separation

Characteristics of Peraclean® Ocean

- **Liquid**
- **Handling as other disinfection fluids**
- **Easy to apply (e.g. injection during ballast water intake)**
- **Can be delivered in: 220 kg-drums, 1.1t- IBCs,**
  20 tons-ISO-containers
- **Proprietary formulation based on peroxy acetic acid**
- **Long shelf-life (still >95% activity after one year storage at 20ºC)**

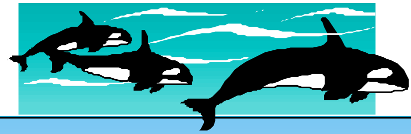
Peraclean® Ocean

- **Short half-life (hours to days) depending on water salinity, pH and temperature**

- **Degradation products are readily biodegradable**

- **Applicable to marine, brackish & freshwater**

Acknowledgements



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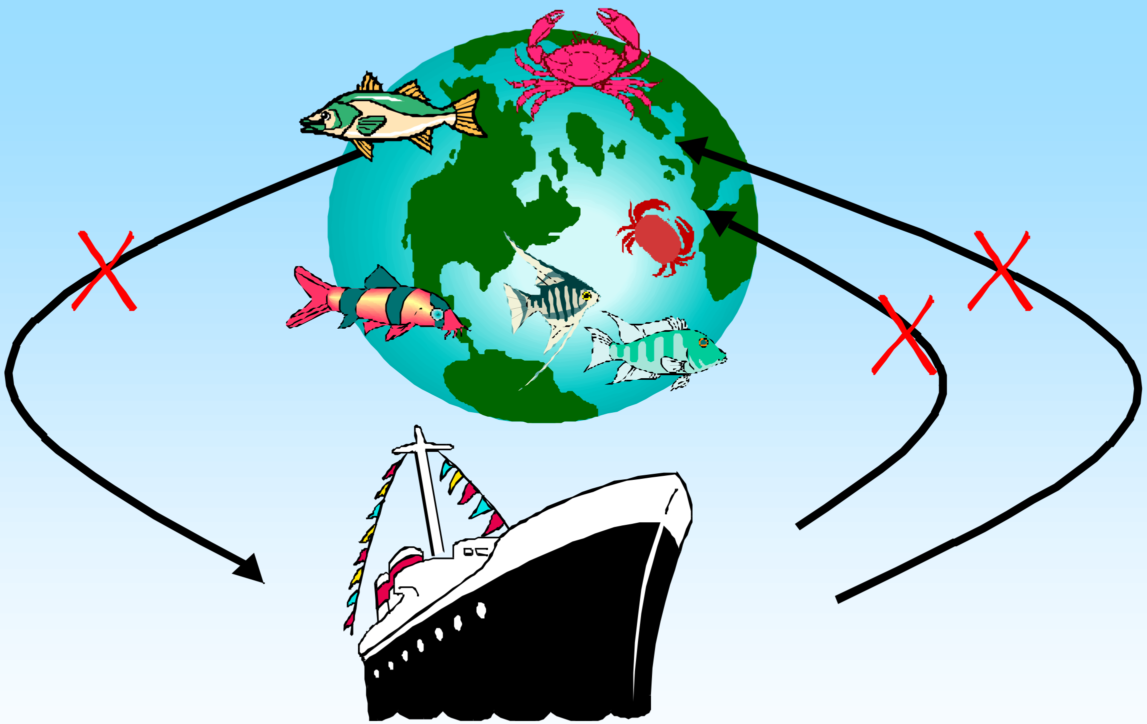
- **Hamann Wassertechnik, Germany**
- **Prof. Dr. H. Rosenthal,**
  Institute for Marine Research, Kiel, Germany
- **Dr. Matthias Voigt, Stolpe, Germany**

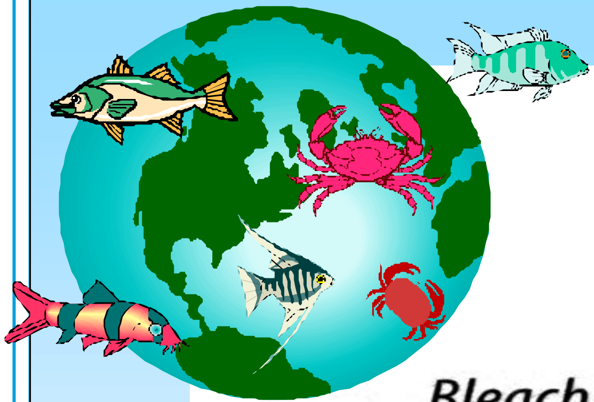
Peraclean® Ocean -



a viable alternative for ballast water treatment.

Contact Adress

„Ballast Water Treatment“ and „Waste Water Treatment“



degussa.

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CURRICULUM VITAE

CV Birgir Nilsen, OptiMarin AS

Birgir Nilsen has Master of Business and Marketing degree from Oslo Business School.

He founded Connor AS in Norway with a 3-man partner team in March 1995, with a business plan selling ERP Systems. Together with one of the other partners he was responsible for business development, and developed Connor AS into to a 25-man company with $ 2.5 million in less than 3 years. They brought Connor AS to a merger with another Norwegian company, Customax, at the end of 1997.

Birgir founded Caliber Solutions LLC in January 1998 in Stamford CT on behalf of Customax AS and local partners. He was responsible for sales and business development.

Birgir joined OptiMarin AS in May 2000 and works together with Halvor Nilsen to develop the OptiMar Ballast System and OptiMarin AS into a commercial enterprise.

ABSTRACT

Birgir Nielson, OptiMarin, NO

"OptiMar Ballast System - a practical solution to the treatment of ballast water on ships"

The paper reviews the OptiMar Ballast System ”a practical solution to the treatment of ballast water”. It examines on board ballast water treatment using a solids separation as a pre-treatment and UV light as the primary treatment.
The various components of the system is presented and described including improvements based on the experience gathered in testing and shipboard installation.
The installation of an OptiMar Ballast System aboard the cruise ship Regal Princess is discussed.
The conclusions of the results of the various testing of the system both prior to and after the full-scale shipboard installation are presented. We refer to the respective reports for detailed findings and results.

Further we have included a new development of the OptiMar technology using filtration and UV for Grey Water treatment, more information to follow.

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Chairman

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International Conference, Bremerhaven, September 12-14, 2001

"Ballast Water, Waste Water and Sewage Treatment
on Ships and in Ports"

OptiMarin AS

OptiMar Ballast Systems
A practical solution for the treatment of ballast water on ships

ABSTRACT

The paper reviews the OptiMar Ballast System “a practical solution to the treatment of ballast water”. It examines on board ballast water treatment using a solids separation as a pre-treatment and UV light as the primary treatment. The various components of the system is presented and described including improvements based on the experience gathered in testing and shipboard installation. The installation of an OptiMar Ballast System aboard the cruise ship Regal Princess is discussed. The conclusions of the results of the various testing of the system both prior to and after the full-scale shipboard installation are presented. We refer to the respective reports for detailed findings and results.

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Introduction

The OptiMar Ballast System is based on solids separation, filtration and UV irradiation and uses the existing ballast pumps, pipelines and ballast control system aboard the vessel. The system can handle flow rates from 1 m3/h up to 3000 m^3/h per ballast pump.

The MicroKill Separator removes larger suspended solids. The MicroKill Filter removes all solids down to a desired micron size including organisms. The components can be used together with the MicroKill Separator in front or separately depending on the expected conditions or the level of treatment desired. For smaller ballast systems the Filter is relatively economical and practical and is recommended. The Separator is recommended for higher flow systems.

The MicroKill UV destroys or inactivates biological organisms including zooplankton, algae, bacteria and pathogens from ballast water without affecting the normal operation of the ship. Ballast water is also treated during de-ballasting to ensure the maximum effect.

The system is currently in operating on 2 cruise vessels from Princess Cruises the Regal Princess (200 m3/hr capacity) and the Sea Princess (220 m3/hr capacity), and there are 3 installations in process, the MV R.J. Pfeiffer a container vessel from Matson Navigation Company (350 m3/hr capacity), the Stolt Aspiration a product tanker from Stolt Nielsen (250 m3/hr capacity), and the Star Princess from Princess Cruises (255 m3/hr capacity).

OptiMar Ballast Systems Capacities

MicroKill Separator

Capacity:	1 - 3000 m^3/h
Materials:	Stainless Steel 316 L/ CuNi 90/10

MicroKill Filter

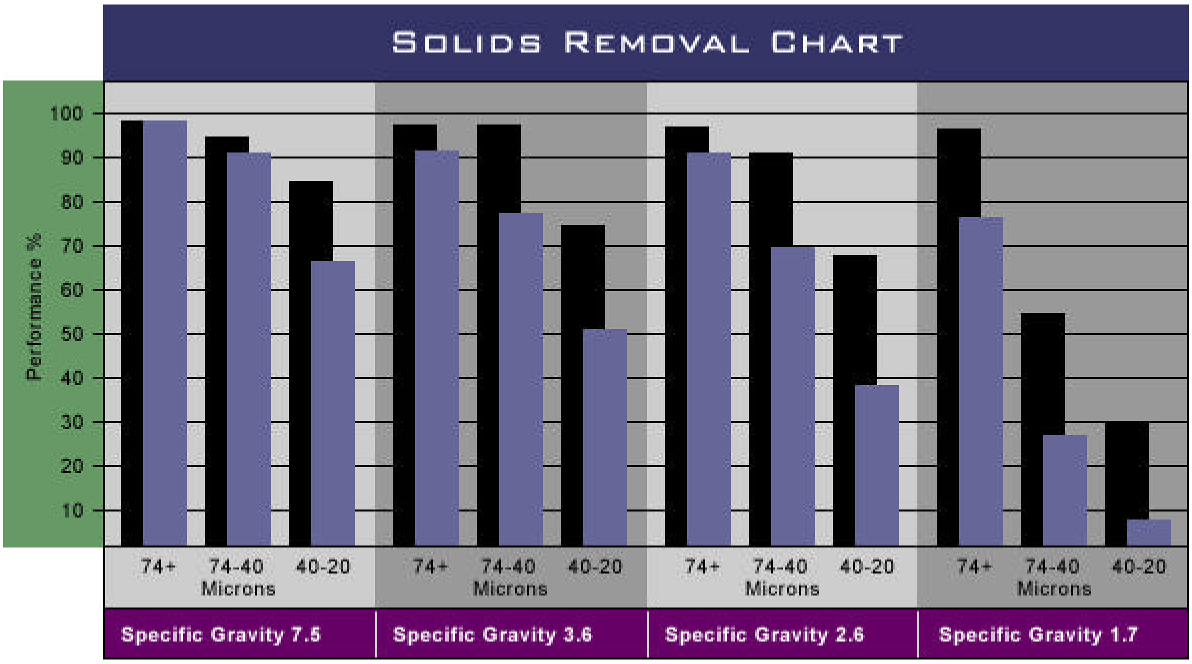
Capacity:	1 - 700 m^3/h
Materials:	Stainless Steel 316 L/ CuNi 90/10

MicroKill UV

Capacity:	1 - 3000 m^3/h
UV Dose:	120 mWs/cm2
Materials:	Stainless Steel 316 L/ CuNi 90/10 90/10
Power:	1,2 - 58 kW

MicroKill Separator

Ballast water enters tangentially, setting up a circular flow. Liquids and solids are drawn through the patented Swirlex slots. Centrifugal action directs particles heavier than the ballast water to the perimeter of the separation chamber. The sludge is collected in the lower chamber and continuously bled through the sludge discharge pipe and back into the harbor. The "clean" ballast water flows to the outlet pipe on top of the unit. Simple controls regulate the balance of flow between clean water and sludge and measure the ship's draft and system pressure to ensure sludge discharge overboard. Pressure drop is minimal and only 5% or less of the ballast water flow is discharged with the sludge.



MicroKill Filter
MicroKill Filters use special stacked filter disks. The disks are color-coded by micron size, and are assembled according to the specific filtration requirements. The disk assembly has a spring compression unit and an internal piston, which operate during alternate filtering or back flushing modes.
The disk and spine assembly is specially designed to compress the micron-grooved discs inside a corrosion and pressure resistant housing. The MicroKill Filter can be configured in any orientation and fitted into existing available space. The MicroKill Filter has a very low-pressure drop and requires only about 0.25% of the flow for back flushing.

MicroKill UV
The UV is designed for efficient kill or inactivation of organisms, bacteria and pathogens in ballast water. System design is based on 20 years experience with water injection on offshore platforms, water treatment for fish farming, and drinking water plants in Norway. The system has a very low-pressure drop to minimize its effect on ballast pump capacity. The MicroKill UV is a minimum maintenance system and has low power consumption compared to capacity.

Each microorganism must absorb a specific UV dose to be destroyed; the UV penetrates the bacteria wall and is absorbed by the DNA consequently destroying life and preventing reproduction. The MicroKill UV is designed for efficient inactivation of organisms with a very low-pressure drop to meet the requirements of ballast systems and pumps.

UV light, when used in the wavelength ranging from 215 - 315 nm (nano-meter) the UV-C spectrum will cause irreparable damages to the DNA in bacteria & microorganisms. The most potent and effective wavelength for the damage of the DNA is 253,7 nm.

Both low pressure and medium pressure UV lamp systems are available. The choice depends on system capacity and the most efficient and cost effective design for the particular ship is offered.

UV Control Panel

The MicroKill UV is delivered with power and control panels. The control panel monitors and logs the performance of the UV system and has a continuous performance log. The control system also ensures that all water passing through the UV chamber receives at least the minimum prescribed UV dose.

The control panel is also equipped with a self-diagnostic system and will alarm if the performance is below the specified intensity due to unclean quartz tubes, reduced water quality or if a UV lamp needs to be replaced.

Advantages OptiMar Ballast System

- Reduce sediments in ballast tanks
- Simplicity, no moving parts
- Minimal impact on existing ballast system
- Can easily be incorporated into the existing ballast system
- Modular installation
- Low cost of operation
- Reduced emissions compared with Ballast Water Exchange
- No chemicals required
- Safe for ship and crew
- Economical first cost

History

The OptiMar Ballast System was developed based on 20 years experience in the offshore and the fish farming industries and from the supply of drinking water plants in Norway.

The idea for the 'OptiMar Ballast Systems'' was first conceived, after an inquiry from the Norwegian Department of Shipping in 1995. The concept of ''OptiMar Ballast Systems'' was developed and presented to the Department of Shipping in May 1997.

The development of the MicroKill UV, a UV system for fish farming and ships was started in early 1998, based on previous experience in manufacturing and application of UV systems. The prototype was sold to the fish farming industry on the day it was completed. In the fall of 1998 another 5 systems were delivered, each with flow rate capacity of 1000 m^3/h.

Testing 1998

The OptiMar Ballast System was tested for the first time at the Institute of Marine Research, Austevoll Aquaculture Research Station. The results were promising and were presented in the report "Testing ballast water treatment by low G-force vortex separation and UV-Radiation". By Anders Jelmert, Institute of Marine Research, Norway 1998. The report was also presented at the IMO meeting MEPC 42.

Testing 1999

In March 1999 another test funded by OptiMarin AS was conducted at the Institute of Marine Research, Austevoll Aquaculture Research Station, with a different separator. The result was similar to the tests conducted in 1998. The test results are available at http://www.optimarin.com/Tests.htm

In April 1999 OptiMarin AS participated in a test in Vancouver, Canada, together with Terri Sutherland, Research Scientist, Marine Environment and Habitat Science Division, West Vancouver Laboratory, Fisheries and Oceans Canada. The result was similar to the test at Austevoll. The test report was published in volume 210 of the Marine Ecology Progress Series Journal. The test results are available at http://www.optimarin.com/Tests.htm

The separators used in the Vancouver tests had a pressure drop that made them unsuitable for use in ballast water systems without changing the ballast pumps and the size of the equipment would make installation on a ship very difficult.

Between May and September 1999 OptiMarin AS, therefore, conducted tests with several different hydro cyclone separators. After numerous tests we found a model that separated sand from water without a major pressure drop. This resulted in the MicroKill Separator. Further development is taking place in Norway and at research institutions in England and Jordan.

Testing 2000

Allegra Cangelosi from the Northeast-Midwest Institute in Washington, DC together with an international group of scientists conducted initial biological tests aboard the Regal Princess in May. The tests are conducted on a 4-day voyage between Vancouver and Alaska. The same team conducted more extensive tests aboard the Regal Princess on a 2-week voyage in August.

OptiMarin AS and Hyde Marine, Inc. also supplied the OptiMar Ballast System for "The Great Lakes Ballast Technology Demonstration Program" (GLBTDP) during the late summer of 2000. A preliminary report combining the findings on the Regal Princess and "The Great Lakes Ballast Water Demonstration Project was presented at the IMO Ballast Water Symposium in April 2001 and we are awaiting the final findings and conclusions of the tests in a published report. The preliminary test results are available at http://www.optimarin.com/Tests.htm

Testing 2001

The "second generation" OptiMar Ballast systems will be of a similar but updated design with improved performance in accordance with the lessons learned aboard the "Regal Princess" as described under lessons learned. The primary improvements are enhanced solids separation performance for the cyclonic separator and a higher dosage rate and improved UV transmission capability in the UV system.

OptiMarin AS together with Hyde Marine Inc. is supplying filters and UV for The Great Lakes Ballast Water Demonstration Project tests for 2001. The filters are 100 micron automatic back flushing disc filters from Arkal in Israel and the UV unit has an improved design for higher UV intensity without increasing power consumption.

We have also together with Hyde Marine delivered a new improved OptiMar Ballast System to the Cruise ship Sea Princess and this installation will be tested by Moss Landing Marine Laboratories (MLML) under a contract with the California State Lands Commission (CSLC) will conduct Independent testing in October.

Moss Landing will also conduct test aboard the Matson's Panamax containership "R. J. Pfeiffer" (350 m3/hr capacity) will also test this system under a similar contract from CSLC in November 2001.

Testing 2002

The testing that is planned for 2002 is the new system to be delivered for the 12,000 DWT parcel tanker, "Stolt Aspiration" (250 m3/hr capacity) that routinely trades between northern Europe and the Great Lakes and St. Lawrence Seaway. This system will be designed to meet explosion proof requirements for installation in the ship's pump room. Installation will begin in September and will be completed in the fall or winter of 2001/2002. Testing is planned to commence at the beginning of the 2002 Great Lakes Shipping season. The testing would be conducted by the GLBTDP.

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Princess Cruises

In April 2000 the OptiMar Ballast System was installed aboard the Princess Cruises "Regal Princess", by OptiMarin and our US partner Hyde Marine, and is the first ballast water treatment system aboard an operating vessel.

The "Regal Princess" takes on and discharges ballast water at a rate of 200 m^3/h (880 US GPM) as fuel and other consumables are used. The OptiMar Ballast System was installed aboard the "Regal Princess" during a regular scheduled two-week cruise from Southern California along the Mexican West Coast in late March 2000. There were no interruptions to the ship's normal operations. The system is compact enough to be located in the ship's pump room. The ship's existing ballast piping system, ballast pump(s), and control valves and systems were used as much as possible to minimize the total installation cost.

The OptiMar Ballast System has operated continuously since mid May 2000 during every ballasting and de-ballasting operation. The ship has reported no problems and no down time on the system. Preliminary onboard testing has indicated significant reductions in organisms, bacteria and pathogens as a result of treatment with the OptiMar system.

We have the following statement from Princess Cruises dated 10/10/2000

> *I confirm that to date we have not had any down time and it is being used for all ballast operations on and off the vessel.*
>
> Lars Nordin, VP Technical Services

George Wright, Director of Compliance & Security, Princess Cruises confirmed that is still the case, in a California State Lands meeting on January 31st 2001.

Princess Cruises have confirmed their satisfaction with the OptiMar system and ordered 2 new systems in the summer of 2001. The second system was installed aboard the cruise ship "Sea Princess" (220 m3/hr capacity) during August 2001 and will be operational in September. The third system will be installed on the "Star Princess" (255 m3/hr capacity), which is currently under construction. The system will be delivered in November 2001 and installation and start up will take place in late 2001 or early 2002.

For more information on the experiences on

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Aims and objectives

The objective in developing the OptiMar Ballast system was to be able to offer an effective and practical solution for the treatment of ballast water on ships and also to be able to retrofit to existing seagoing vessels and to participate in new buildings.

An important consideration is that our system should not to interfere with the existing ballast system. We have emphasized our design to minimize the pressure drop, both trough the solid separation and though the UV, and also to minimize the extra work involved needed to run the system.

Designing A Ballast Water Treatment Process with Solids Separation & UV Irradiation

1) Establish the dose required for treatment
   a) IMO, Harbor Authorities, Water Analyses
2) Determine flow rates required
   a) Ballast pump capacity
3) Establish UV transmission values
   a) Harbor Authorities, water analyses
4) Consider re-circulation if applicable
   a) Use stripping or main pumps
5) Treat water during de-ballasting

Installation

One of the objectives of the OptiMar Ballast System is to be able to retrofit the system into existing vessels, and the installation on the M/S Regal Princess has confirmed that we can do that, and that the installation can be done under operating conditions.

The installation aboard the Regal Princess was carried out "on the run" during two cruises in March 2000. Two fitters completed the job in about two weeks. The ship's ballast piping was cut in only two places and no other modifications to the machinery space were required. The total installation cost was less than $15,000 with no loss in operating time. Only two connections into the ship's existing ballast system piping were required, as shown in the diagram below. No fixed equipment had to be moved and nothing had to be rerouted to accommodate the installation.

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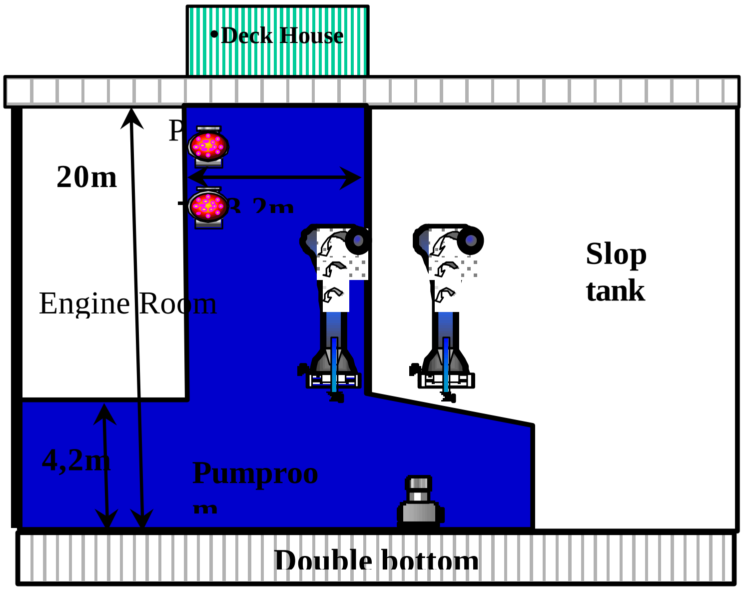
Installation in progress on the Sea Princess. The MicroKill UV chamber is hanging in the air and MicroKill Separator is standing horizontally to the left.

Where to install

- In pump room shaft
- In pump room if space
- In engine room
- Void spaces



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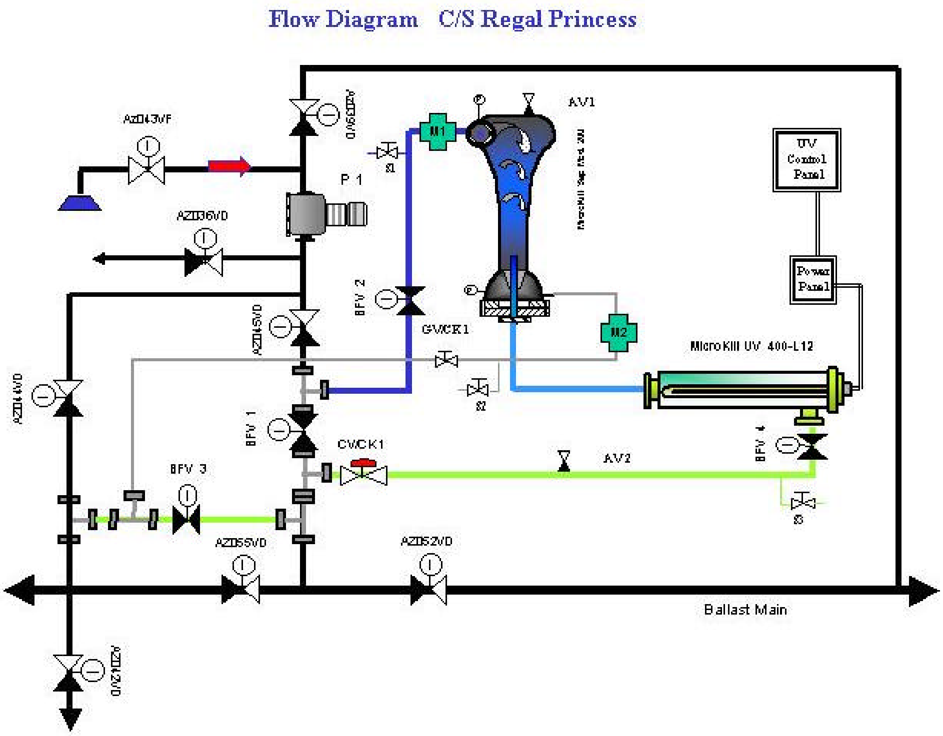
How to install
In a By-Pass line after ballast pumps

OptiMar installation on the Regal Princess



Lesson learned

Among the lessons learned from testing aboard the *Regal Princess* is that a treatment system based on cyclonic separation of solids and UV irradiation will perform reliably aboard an operating commercial ship. During continuous operation since April 2000 the system has required no operator attention and essentially no routine maintenance. It was easily adapted to the ship's existing ballast pumps and had no measurable effect on the ballasting time or the normal operation of the ballast system.

The application on board a cruise ship, however, is not fully representative of the majority of commercial applications as the ballast volume and pumping rate are relatively low. In addition, the ballasting and de-ballasting procedures are relatively straightforward and uncomplicated. A cruise ship normally takes on ballast away from port in relatively small volumes and ballasts and de-ballasts only through the ballast pump. Also there are no high or side ballast tanks in use that require significant ballast pump discharge head.

Testing an essentially identical system on board the test barge did allow testing with a heavier solids loading during ballasting. It also confirmed the biological testing procedures and results obtained aboard the *Regal Princess*.

Installation of the ballast water treatment equipment aboard the *Regal Princess* was straightforward and required no significant relocation or rerouting of existing equipment. The OptiMar equipment also fit easily into an area adjacent to the ballast pump. While, as mentioned above, the *Regal Princess* installation is not necessarily representative of most commercial ships, it does confirm that this type of equipment is suitable for shipboard installation. The system's components are fully scalable up to the highest required ballast pump flow rates, 3000 m3/hr or higher.

Obtaining accurate and useable scientific data on board an operating ship, even a cruise ship, is a difficult task. It requires very careful planning and preparation and a competent and dedicated field-testing team. A cooperative and supportive ship's management and crew are also essential to success. Again the barge testing, using essentially identical equipment and the same test protocol and test methods, was very helpful in confirming the validity of the shipboard results.

It was established that UV treatment should be carried out during de-ballasting as well as during ballasting. The onboard tests indicated that there is significant re-growth of bacteria in the ballast water while it is resident in the ballast tanks. This re-growth could be due to resident bacteria in the ballast tanks from other sources or to the re-growth of the small percentage of the bacteria that was not killed in the treatment during ballasting. Most likely, however, residence time in the ballast tanks is conducive to bacterial re-growth and/or repair.

Additionally, the onboard testing showed that UV treatment during de-ballasting increased the mortality of zooplankton. This confirms the value of treatment during de-ballasting as well as ballasting.

A significant lesson was learned regarding design capacity of the UV system. As reported in Cangelosi et al. (2001), "The UV transmittance of source water, especially resulting from dissolved compounds, which cannot be removed with physical separation devices, strongly influences system performance." Future systems must therefore be rated on the basis of the minimum expected UV transmittance. Information on transmittance values in various ports and other ballasting locations that the ship is likely to encounter must be evaluated to determine the required UV dosage. A corollary to this is that proper ballast management practices must include avoiding ballasting in areas of low UV transmittance, if possible.

The testing also showed that the UV dosages available during the *Regal Princess* and barge testing were not 100% effective against the microorganisms encountered. Future OptiMar systems will have improved UV chamber design to insure that all of the ballast water receives the highest possible dosage. They will also have higher dosage capabilities to improve performance against NIS and bacteria as well as to provide adequate UV irradiation in water with lower UV transmittance.

Barge testing was also done for automatic back flushing screen filtration followed by UV and is reported in Cangelosi et al. (2001). This testing showed that filtration in combination with UV combines the effectiveness of filtration against zooplankton and some phytoplankton, with the biocidal effects of UV on microbes and smaller phytoplankton. OptiMarin and Hyde Marine have, therefore, undertaken the development and testing of the MicroKill Filter to provide this improved performance with a reliable automatic back flushing filtration system. The filters have very low-pressure drop and back flush volume. They are modular and can be delivered in almost any orientation and construction to adapt to the space available on a particular ship. Performance testing will be conducted to determine if improved system performance can be attained without significantly compromising the unattended operation, simplicity and reliability of the OptiMar system.

The results of the onboard and barge testing have provided needed and valuable feedback for several improvements to and the ongoing development of the OptiMar Ballast Treatment System. They have also encouraged OptiMarin and Hyde Marine to continue and, in fact, to step up the development and marketing of the OptiMar Ballast treatment System.

Feedback from Princess Cruises and from other owners and operators, considering the installation of ballast water treatment systems, has confirmed that simplicity and minimum operator attention are primary considerations. Automatic operation and reliability will be important parts of ballast water treatment system specifications. This has confirmed the need to develop systems such as the one aboard the *Regal Princess* with no moving parts and the highest possible level of reliability and trouble free operation.

Ongoing performance testing is being conducted to increase separation performance and minimize the pressure drop in the cyclonic separator to avoid increased ballasting time or problems topping up wing or side tanks and to reduce the sludge volume. Computational fluid dynamics (CFD) projects for modelling the flow within the Separator to improve performance are also underway.

Reducing the size to flow ratio and improving the performance of the UV system will be a continuing effort and challenge. A UV system using medium pressure multi wave technology UV lamps has been developed and will be certified for Explosion Proof installation.

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New Developments / OptiMarin R & D

Our involvement in test projects mentioned above and the experiences from the shipboard installation on Regal Princess and the participation in the Great Lakes Project barge testing have given us invaluable feedback to be able to improve the performance of the OptiMar Ballast System.

MicroKill Separator

- Increase separation performance and minimize the pressure drop to avoid increased ballasting time or problems topping up wing or side tanks.

- Project with University of Herefordshire, Hatfield, UK and University of Amman, Jordan, for modelling of flow and Computational Fluid Dynamics within the MicroKill Separator.

- Utilizing new materials to avoid corrosion by seawater in the separator.

- Ongoing performance testing of the Separator to improve separation and minimize pressure drop and the volume of the sludge water slurry.

MicroKill Filter

OptiMarin AS has been evaluating various types of filters in addition to or instead of the separator where applicable. New back-flushing systems have been developed to meet the requirements on ships. The ‘’MicroKill Filters’’ can be delivered in almost any orientation and construction to adapt the filter to the space available on a particular ship.

Due to the corrosive atmosphere in seawater OptiMarin AS selects the best materials for seawater applications. It is very important to select filters with minimum pressure drop to avoid significant reductions in ballast pump capacity.

MicroKill UV

The objective of our new developments has been to reduce the size to flow ratio and to use new materials to meet the corrosion problems in seawater. This will be a continuous effort and challenge.

Our low-pressure UV systems have new internals that enable us to increase the UV dose without increasing the energy consumption.

We have designed a new UV system using medium pressure multi UV lamp systems with the new Multi Wave Technology. The new UV system uses power from 1 kW UV-C to 58 kW UV-C per unit.

The design UV doses are 150 mWs/cm^2 for capacities up to 3000 m^3/h per pump and 90% UV transmission in T_{10}. If required higher UV doses may be applied.

UV for tankers

In tanker cargo pump rooms where also the ballast water pumps are installed the area is classified as Hazardous Areas for installation of electrical equipment.

New systems will be designed and certified to EEx (p), Pressurised systems for installation in gas area Class Zone II or Cargo Pump Room.

The certification and tests will take place at the end of 2001. The new system will be certified to Explosion Proof installation in gas area Class Zone II or Cargo Pump Room.

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Scientific Research

The research that has been done with the OptiMar Ballast System and its components has been done in cooperation with researchers from all over the world. We have participated in several test projects and the findings are referred to in this paper and is also available on our web site www.ballastwater.com .

The test protocol and testing methods used for the full scale testing of the treatment system aboard the Regal Princess are described in Allegra Cangelosi presentation at this Symposium.

System performance

We have included a summary of the different tests we have participated in and the most important finding is referred to below.

Removal
Consistently reduce culture-forming units of bacteria on a marine agar more than 90%
Consistently reduce the MS-2 coliphage virus by over 90%
Significantly reduce the concentration of live zooplankton relative to controls
Significantly reduced phytoplankton growth potential relative to controls

Practicability
The shipboard installation aboard the Regal Princes has been very successful in terms of reliability and has confirmed that the OptiMar Ballast System is suitable for on-board installations. The test results (se Cangelosi et al. (2001)) are promising and document the efficiency of a ballast system under real operating conditions.

Cost effectiveness
The OptiMar system was designed from the beginning to be both efficient and cost effective. The modular design and the availability of optional methods for solids separation and the most suitable UV design help to minimize both the system's initial cost and the cost of installation and operation. It is important to mention that it is possible to install more effective component such as more powerful UV for increased kill rate and more effective filters for higher removal of particles, but this will highly increase the cost for installation and operation of the equipment.

Safety implications
There are no crew or ship safety concerns with the OptiMar Ballast System. We are in the process of certifying the system to Explosion Proof - for installation in gas area Class Zone II or Cargo Pump Room.

Tests results

1. 1998 Tests at Institute of Marine Research, Austevoll Aquaculture Research Station, Norway.

Test Method

Water was pumped from the sea at a rate of 50 m^3/h. A low G-force separator was installed after the pump for pre-treatment, for removing suspended solids, sand, seaweed and uni- and multicellular organisms.

A medium pressure single chamber UV unit was used for secondary treatment. The single UV lamp had a UV power of 5,8 kW nominal and a UV-C power of 850 W. Applied dose at 254 nm was 93 mWs/cm^2Calculated from the flow and UV transmission. Sample injection was 0,8 l/min and purge 15 l/min, or about 2% of the flow.

Summary of Results,

- Mortality of the model zooplankton (Artemia sp.) was 100% after UV-treatment.
- Removal of Cysts of model zooplankton: 81%
- The algae Isochrysis galbana and Pavlova sp. had a mortality of 100% and 85%, respectively.
- No signs of photorepair observed.
- The 2 bacterial strains were killed with an efficacy greater then 99.9995%.

Conclusions

- The mortality of several aquatic organisms was 100%, or in the 99% range
- The mortality of UV-adapted organisms was 85% (one Algae) and 81% (Artemia cysts)
- Particles <40 µm was not effectively removed in the separator
- The method can be expected to reduce transfer success significantly.

See details of the report on our web site www.ballastwater.com .

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2. 1999 Tests at Institute of Marine Research, Austevoll Aquaculture Research Station, Norway.

Executive summary.

- This report describes the results obtained in a semi-scale laboratory test of an integrated hydro cyclone-UV unit, designed for removal of exotic species in ballast water.

- The scope of the treatment was to remove as much as possible suspended solids and uni- and multi cellular organisms in a hydro cyclone, and to kill the remaining biota by UV irradiation, which has maximal biocidal activity at 254nm.

- The applied dose is dependent of flow and the transmissivity of the water. To ensure a good «signal to noise» ratio in the test, dense cultures of Artemia sp, naupleii, Artemia cysts, the dinoflagellate Prorocentrum minimum, the green algae Tetraselmis sp., and two isolates of marine bacteria was injected into the water flow.

- Except for the extremely UV-resistant Atremia-cysts, the tested equipment (Hydro cyclone + UV irradiation chamber) did remove model zooplankton, two species of marine alga, and a community of marine bacteria to a higher percentage than practical trials with ballast water exchange have accomplished.

- The hydro cyclone utilized was not found suitable as a singular treatment option, but hydrocyclones may function as a suitable pre-treatment for UV irradiation.

Abstract from the report.

- The removal of particles, and mortality of the various biota at four consecutive stages through the treatment system was recorded.
- Cysts of the brine shrimp Artemia sp. were removed at an efficiency of 13.7% in the hydro cyclone, and the naupilus-larva of Artemia were removed by an efficiency of 8.3%.
- Through the UV-unit, the naupleii showed a mortality of 99.5% and the numbers of hatching of cysts was 26 % lower than the numbers before the unit.
- The microalga were removed with an efficacy in the 10 - 30 % range in the hydro cyclone, and showed a mortality in the UV-unit of 84.7% and 87.6 %, respectively for P. minimum and Tetraselmis sp.
- The removal of bacteria in the hydro cyclone was negligible; while the bacterial numbers were reduced corresponding to a -2.3 log and -1.9 log elimination respectively, in two separate trials.

The complete report can be downloaded from our web site www.ballastwater.com or ask for a paper copy.

3. 1999 Tests by Fisheries and Oceans Canada, Vancouver, Canada.

A field test was carried out in the port of Vancouver in April 1999. The treatment system consisted of the same type of separator, Velox, and MicroKill UV as in the previous test at Institute of Marine Research only designed to a higher capacity. The Cyclone and UV used at IMR were designed at 120 m^3/h while the actual flow during testing was 75 m^3/h average. At the Vancouver test the equipment used were for 1000 m^3/h, but the actual flow average was 330 m^3/h during testing.

Abstract from the Report

A field experiment was carried out to determine the influence of a 2-stage ballast water treatment system on the survivorship of natural populations of plankton. This Integrated Cyclone-UV Treatment System (ITS) was designed and constructed by Velox Technology Inc. and consisted of 2 treatment phases: (1) the cyclonic pre-treatment phase, (2) the ultraviolet-radiation phase (UV-C). The ITS was deployed on the Vancouver Port Authority dock, British Columbia on April 11, 1999. Seawater samples were collected from ports located along the treatment stages of the ITS and analyzed for plankton survivorship. The sampling stages were defined as Pre-Intake, Pre-Cyclone, Post-Cyclone, Post-Solids, and Post-UV-on and Post-UV-off. The survivorship of planktonic invertebrates was assessed immediately through direct observations, while phytoplankton survivorship was assessed through incubation grow-out experiments. With respect to zooplankton, live copepods were observed in the Pre-Intake and Pre-Cyclone samples, while dead or moribund copepods were observed in samples collected from both early and late stages of the ITS. Statistical comparisons were carried out on phytoplankton growth parameters such as starting concentration, lag phase, growth rate, and relative abundance generated during the incubation experiment. *Chaetoceros gracile* appeared to be the most sensitive organism to the ITS as it exhibited a 4 d lag phase prior to growth. The starting concentration, growth rate, and relative abundance of this species observed in the Post UV-on samples were significantly lower than those observed in the Pre-Intake samples (control). In addition, the auxospores formed by *Skeletonema costatum* during the incubation experiment were observed in all treatment samples with the exception of those exposed to the Post-UV-on stage of the ITS. A second phytoplankton incubation experiment was carried out using the original samples following a 3 mo storage period in dark, cold conditions (4°C). The results of this experiment revealed that the phytoplankton population in the UV-treated samples was not capable of growth, while those in the remaining treatments exhibited growth. Thus, future studies assessing the effect of the ITS on phytoplankton survivorship should incorporate increases in the intensity and exposure period of ultraviolet radiation followed by a dark, cold-storage period, thereby reducing the chance of photorepair.

4. 2000 Tests on Regal Princes and the Great Lakes Ballast Technology Demonstration Program by Allegra Cangelosi, Northeast-Midwest Institute and collaborators

The experiments reported here were designed to describe the biological effectiveness of the OptiMar Ballast Treatment System at killing, removing, or impeding reproduction of organisms in ballast water (operational findings will be reported elsewhere). Extensive physical and biological tests were conducted on the system on both a stationary barge-based experimental platform at 1500 USGPM, and in an engine-room installation of an operating passenger vessel (*MV Regal Princess*) at 880 USGPM. The barge-based tests illuminated system effectiveness in a high flow, yet controlled experimental context. The ship-board tests provided a real-world assessment of the treatment in the context of an operating ballast system. While not all-encompassing, the combination of biological findings reported here provide a strong indication of overall system effectiveness with respect to bacteria, viruses, phytoplankton and zooplankton. Though the full-scale flow-rate for the passenger ship is low compared to cargo ships, the experiments were also informative as to interactions between ballast systems and the biota in treated and untreated water, and the extent to which efficacy results from a barge platform may be translatable to effectiveness in a ship.

System Performance

1. Performance evaluations at two time intervals following treatment (0 hours and 18-24 hours), in two treatment contexts (actual ship ballast system, and a barge-based platform), and varied locations with diverse physical/chemical water conditions (Pacific Northwest coastal, and two Lake Superior locations) revealed system effectiveness at elevating zooplankton and phytoplankton mortality, and inhibiting phytoplankton and microbial growth.

2. Both CS and UV contributed to zooplankton mortality, while the UV system alone caused phytoplankton and bacteria inactivation.

3. The shipboard system, which treated water on uptake and discharge, elevated zooplankton mortality two and a half fold relative to controls. Treatment upon intake caused no immediate zooplankton mortality, but did cause latent mortality. Immediate zooplankton mortality was evident upon treatment of the discharge stream in both T0 and T18-24 studies, indicating that the intake treatment, short or long-term storage in a ballast tank, and/or a slower pump rate upon discharge may contribute to zooplankton susceptibility to the treatment. The overall decrease in live density of zooplankton in T-18-24 treated water following discharge treatment was over 90% relative to intake levels in the shipboard application (compared to a 55% decrease in the controls). The intake-only treatment on the barge platform elevated zooplankton mortality 51% relative to controls. These findings represent a conservative estimate of zooplankton inactivation as latent zooplankton mortality caused by the discharge treatment and

reproductive effects in general were not measured. In addition, moribund individuals were counted as live.

4. The system did not alter absolute chlorophyll *a* concentrations relative to controls through acute effects such as removal or bleaching on either platform. Storage of the water for 18 hours in a catchment or ballast tank prior to sampling did not alter this finding. The system did reduce algal growth and accelerated die-off relative to controls in incubated samples. Chlorophyll *a* concentrations in incubated samples collected 18 hours following treatment by UV alone and CS and UV decreased by nearly 60% relative to controls, while CS alone did not affect algal growth.
5. The system significantly reduced microbial concentrations at all test sites. The mean reduction due to one pass through the treatment system on the *MV Regal Princess* was 82%. Retention for less than two hours in the ballast system raised concentrations of culturable bacteria 1.45 Log higher than levels immediately following treatment. Bacterial regrowth and/or repair during 18-24 hour retention in the ballast tank raised bacterial concentrations 2.62 Log, over twice as effectively as during intake.

6. The UV transmittance of source water, especially resulting from dissolved compounds, which cannot be removed with physical separation devices, strongly influences system performance. Treatment performance characterizations must therefore be qualified by this information, and treatment systems designed for effectiveness for the range of UV transmittance characteristics that the ship is likely to encounter in harbor waters.

7. The effectiveness of the system on bacteria and phytoplankton, while measurable and statistically significant on one or both experimental platforms, might not be biologically significant in terms of the receiving system due to the high capacity of these organisms to regrow. The system may have selectively reduced some types of bacteria and phytoplankton to adequately low levels to be biologically significant. However, it may also have the effect of selecting for organisms that are resistant to UV effects. These tests do show, however, that the technology can be effective against these organisms in field conditions, and with design modifications a greater level of effectiveness these organisms can be achieved.

Conclusions and Recommendations

The OptiMar Ballast System is the first and only full-scale shipboard system in successful operation on any ship. The system has proven to be reliable and effective and is running during every ballasting and de-ballasting operation aboard the Regal Princess. Princess Cruise's commitment and the fact they have ordered another 2 systems is a statement of satisfaction. It is up to the regulators to define the standards for which the system should comply too. As of now we have designed what we believe to be the most cost effective solution for real shipboard installations.

We believe that a full-scale shipboard installation is the only way to verify if a treatment solution is a viable option and practical for the every day operation of the ship. The Regal Princess shipboard installation and the experience gathered from the daily operation of the system and the tests we have participated in have given us invaluable feedback. These have resulted in further improvements to the OptiMar System making it even more efficient and easier to operate for our customers. OptiMarin and Hyde Marine are committed to continuous improvement of the OptiMar treatment technologies.

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Marine Ecology Progress Series Journal volume 210 January 26th 2001

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GloBallast Symposium and Workshop Submission, March 26-30

Mackey, T. P. Hyde Marine Inc,
Private Communication, March 2001

CURRICULUM VITAE

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Nationality	:	Dutch
Education	:	1990 BSc International Land & Water Management International Agricultural College Larenstein 1997 MSc Land & Water Management International Agricultural College Larenstein
Additional education	:	1997 SEFIC exam in English advanced level 1998 Project Management course (Bronx Company) 2000 Refresher course English 2001 Course on Environmental Education at the Open University
Languages	:	Excellent knowledge of Dutch and English, good knowledge of French en German and knowledge of Romanian and Portuguese
Current function	:	Environmental Consultant with IWACO B.V., Consultants for water and environment, Rotterdam, the Netherlands

Key Qualifications:

Ms. Sprong-Wijnreder has both management and environmental degrees. During her one-year permanent residence in Romania, she has been involved in the implementation of Waste Management Systems, training courses, organising workshops and communication strategies. Further she has been working in projects on waste management. This includes waste management planning, waste management in ports, separate waste collection and environmental education.

Working experience

1999 – present	:	Environmental Consultant for Environment International with IWACO B.V.
1999	:	Environmental Consultant for Environment International with IWACO Romania
1996 – 1998	:	Environmental Consultant with IWACO B.V. in Maastricht

Project experience abroad

2001	:	**Baltic States** Organising and implementing Eco-teams in schools in three Baltic States.
2001	:	**Romania** Separate Waste Collection in the city Brasov. The project includes the development of a communication plan and a training on environmental communication, a seminar on public participation, execution and evaluation of two pilot-areas.
2000 - 2001	:	**Divers** Involved in the organisation and management of several major proposals.

2000 – 2001	:	**Bulgaria** Institutional strengthening in the Port of Bourgas; support for the implementation of the Port Waste Management Plan through training and development of procedures; review of port legislation compared to international and EU legislation. Project-management for the complete project.
1999 – 2000	:	**Romania** Bilateral Assistant Expert Within the Port Authority of Constanta (Romania) the BAE supports the implementation of the Waste Management Strategic Plan. This includes internal communistaion, the development of a plan to improve the communication with vessels, organizing workshops, development of a database for the registration of vessel related waste, introduction of IPPC and environmental management systems within port based companies in co-operation with the local Environmental Protection Agency.
1995	:	**Sri Lanka** Development and supervision on installation of a sustainable drinking water supply system.
1994	:	**Mozambique** Technical assistance in the field of land and water management, such as the development of a irrigation system and the introduction of erosion control.

Project experience in the Netherlands

2001	:	Organising and giving courses on the Building Material Decree for the Environmental Protection Agency Ijmond (Milieudienst Ijmond).
2001	:	Courses on the Building Material Decree for the contractor Heijmans.
2000	:	Involved in the organisation of an internal course which is introduction to the international work.
2000	:	Organising and giving courses on environment The Building Material Decree for the city Den Haag.
2000	:	Organising and giving courses on the planning and fieldwork of soil investigations following the Building Material Decree.
1997	:	Within the Province administration responsible for the co-ordination and administration of 1000 soil investigations And thus the implementation of the provincial policy on environmental liabilities management. This included communication with citizens regarding the results and internal communication. It further included the development of standardised methodology for large numbers of detailed soil investigations.
1997	:	Development of the City of Venray, The Netherlands Within this project responsible for the impact assessment of several planned modifications in the cities' water infrastructure.
1996	:	Study regarding problems on Project-management, occurring during implementation of sustainable water management in urban areas.

Other

2000 – present	:	Member of the quality-team for the promotion and improvement of the quality-system within International Projects Division.
2000- present	:	Member of the product-team for the key-product landfills within the company organisation.

Abstract

Frans J. Tjallingii MSc.
Project Manager Shipping and Environment
IWACO B.V., Amsterdam, The Netherlands

"Different Vessels, Different Treatments ?
Possibilities and constraints for ballast water treatment in different vessel types"

The risk of the introduction of aquatic organisms and pathogens through the use of ballast water can currently not be totally eliminated. At present, minimisation of this risk is sought through the on-board treatment of ballast water (BWT).

Standards are under development at the International Maritime Organisation that will formalise the requirements on treatment techniques. The questions analysed in this presentation are: what can ship owners feasibly do?; and what influences will BWT have on ship operations?. Under commission of the Royal Association of Netherlands' Shipowners, IWACO is performing a survey of the technical aspects of BWT for different vessel types.

To gain an overview of the possible application and constraints of BWT on different ships, ten Dutch ship owners were asked to provide information on representative vessels from their fleet. Vessel types included general cargo (deep sea/short sea), tankers (oil/chemical/gas), Ro/Ro, container ships, ferries, passenger vessels and towed objects (pontoons, wrecks and so forth). The technical specifications and operational aspects of these vessels were recorded.

After creating an overview per vessel type from the survey, an analysis will be made of the treatment techniques that are currently under consideration. It is determined whether these techniques can be used, given the layout of the ballast system, its capacity and its flow rates. Then the influence of the technique on aspects such as energy consumption, crew usage, corrosion, voyage or lay-time and other ship operations is assessed.

For some vessels ballast water exchange (BWE) will remain a viable option for the near future, this also depending on the progress of local regulations. For others BWT will have certain advantages in the line of added safety and lower cost. These aspects vary significantly with the design of the vessel and its ballast pattern.

Ballast water: different vessels, different treatments?

Franca Sprong-Wijnreder

Bremerhaven, September 12th, 2001

ROYAL HASKONING

ROYAL HASKONING

September 2001

Different vessels, different treatments?

- **Actual Operations**
  - Home base in Western Europe
  - Branch offices in more than 25 countries world wide
  - Project-activities in over 50 countries

- **Today:**
  - 2,300 employees world wide
  - a broad range of consultancy services
  - turnover of Euro 160 million
  - 40% of turnover abroad

Different vessels, different treatments?

- **Royal Haskoning in the field of environment and shipping**

- **fields of expertise:**
  - Sustainable Shipping
  - Environmental Care
  - Emission Studies and Inventories
  - Health and Safety
  - Ship Recycling Studies
  - (Ballast) Water Treatment

Different vessels, different treatments?

- **Contents:**
  - introduction
  - the project
  - different vessel types
  - differences in design
  - different possible treatments
  - which vessels, which treatments?
  - differentiating criteria between ship owners
  - conclusions

Different vessels, different treatments?

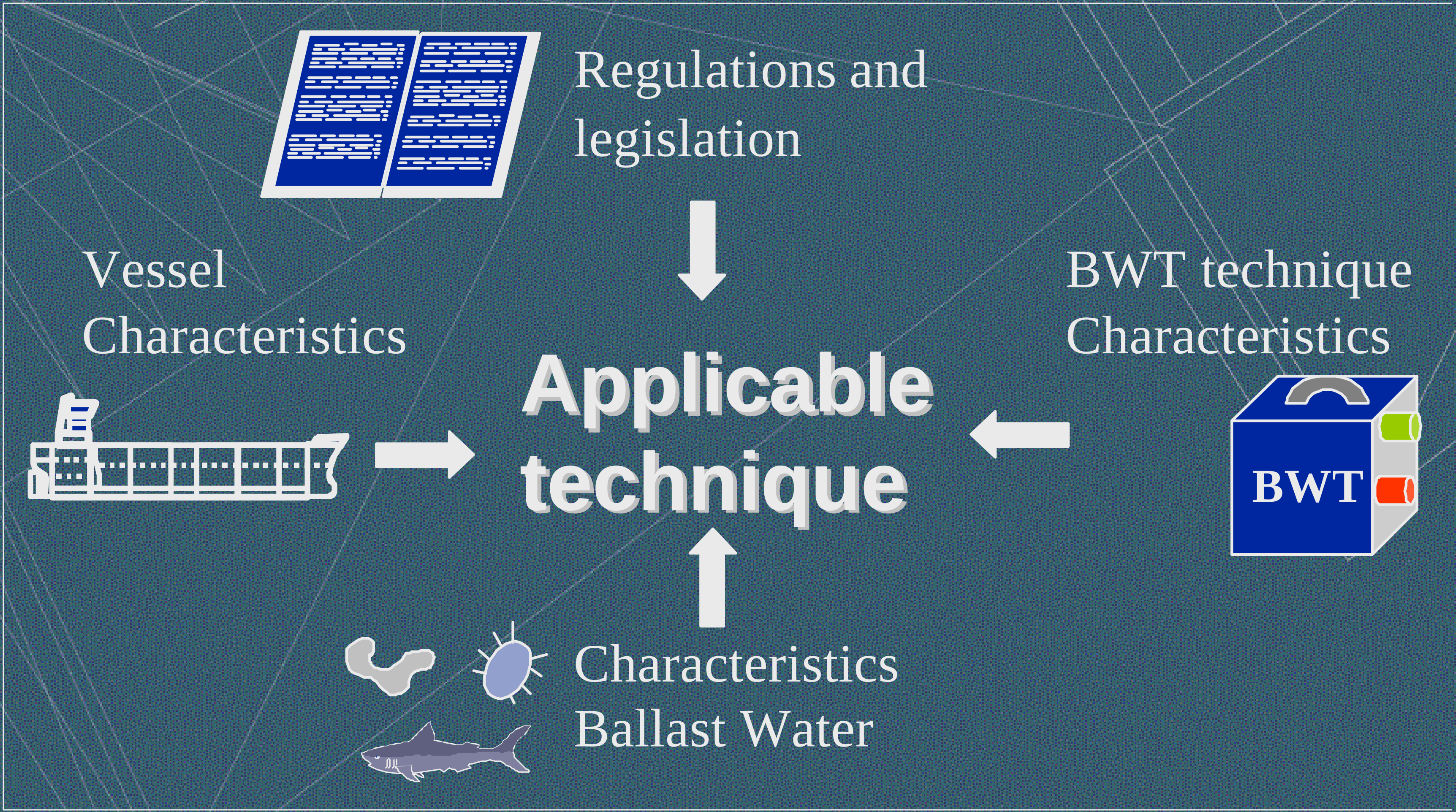
- **Introduction**
  - Ballast water: the problem
  - Ballast water: treatment or exchange

Different vessels, different treatments?

- **The project:**
  - the project
  - client: Royal Association of Netherlands' Shipowners
  - goal: options for BWT for the Dutch fleet
  - activities:
    – survey with different ship owners
    – study of vessel schematics and trade patterns

Different vessels, different treatments?

- **Currently few techniques available**
  - Assessment on a conceptual level
  - Presenting the wishes of ship owners

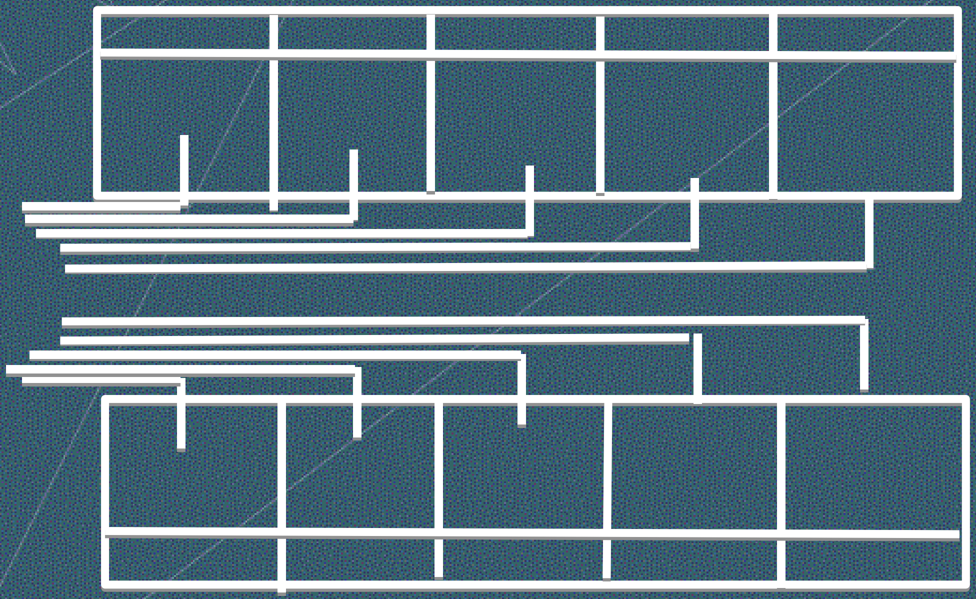

Regulations and legislation
Vessel Characteristics
BWT technique Characteristics
Applicable technique
BWT
Characteristics Ballast Water

Different vessels, different treatments?

- **Different vessel types**
  - The Dutch fleet:
    - Chemical tankers (5%)
    - General cargo (52%)
    - Container / Container feeder (9%)
    - Heavy transport (2%)
    - RoRo (2%)
    - Cruise ships (3%)

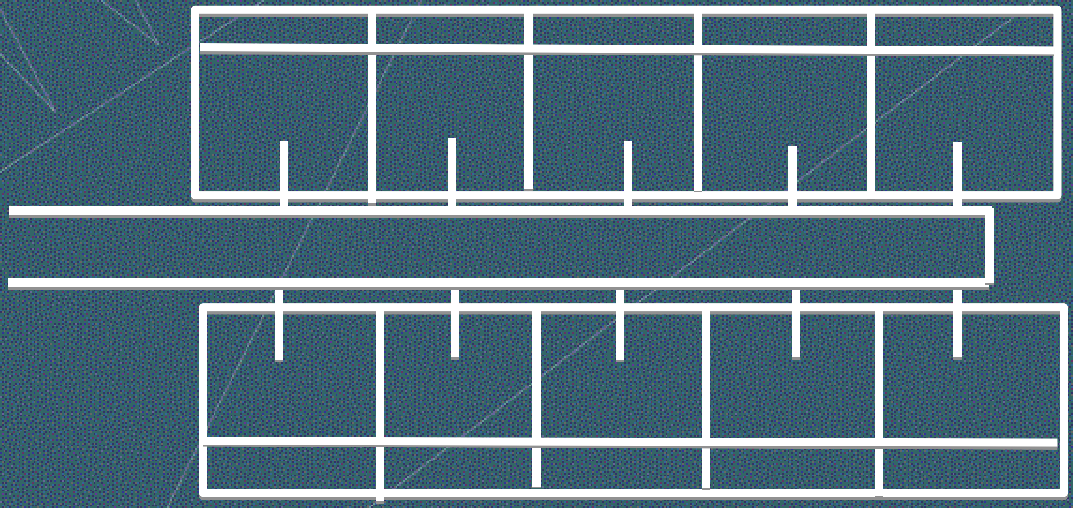
Different vessels, different treatments?

- **Major differences in design**
  - Ballast water piping



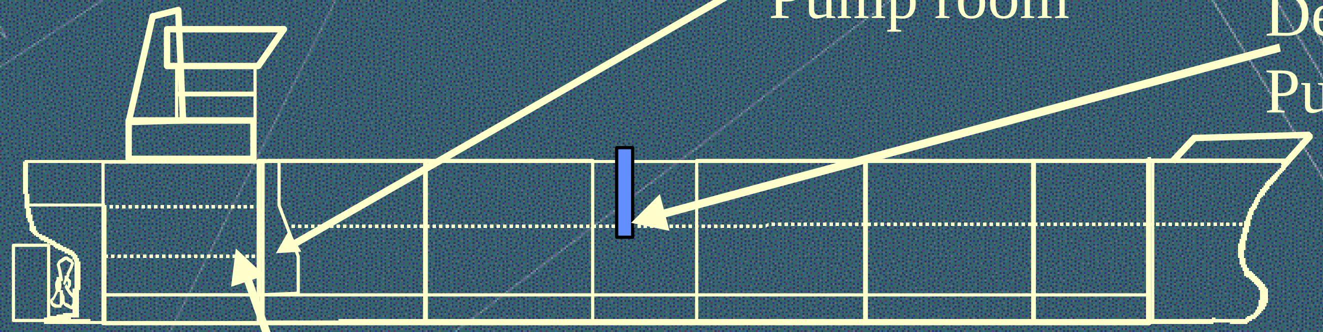
Different vessels, different treatments?

- **Major differences in design**
  - **– Ballast water piping**



Different vessels, different treatments?

- **Major differences in design**
  - **Space for treatment options**



ROYAL HASKONING

Different vessels, different treatments?

- **Different possible treatments**

  - heating
  - chemical treatment
  - filters
  - UV treatment
  - cyclonic separation

  } Combination

Different vessels, different treatments?

- **Which vessels, which treatments?**

Chemical tankers

- Bulk trade or parcel
- Room in pump-room
- No Heat Treatment
- Possibly excess energy

Different vessels, different treatments?

- **Which vessels, which treatments?**

  Container Vessels/ Feeders/ General Cargo/ RoRo vessels

  - Parcel Trades
  - In port ballast maneuvers
  - Less space
  - Small vessels: sediment problem

Different vessels, different treatments?

- **Which vessels, which treatments?**

Submersible heavy lift vessels

- Part of tanks pumped
- Others air pressure
- Many inlets
- Chemicals only option?

- **Which vessels, which treatments?**

  Cruise Ships

  – Low flow rates
  – Membrane Bio Reactor as a possibility

  – No chemicals

Different vessels, different treatments?

- Differentiating criteria between ship owners
  - Trade type determines ballast pattern
  - Trade routes determine relevant regulations

Different vessels, different treatments?

- **Preliminary Conclusions**
  - For each type of ship a different solution may be best
  - Ballast Water Treatment might save costs due to the removal of sediment and prevention of corrosion
  - Heating and chemical treatment are no preferred option
  - Expect:
    - Figures on available space
    - Details on fit of treatment techniques
    - Other vessel specific data

ROYAL HASKONING

September 2001

CURRICULUM VITAE

Cornelius de Keyzer, Master Mariner,

has been involved in the shipping business for 40 years.

After graduating from the Nautical Academy Rotterdam he joined the Holland America Line as a junior deck officer and after a career of 11 years in the Dutch, Liberian and Canadian merchant marine he signed off and joined Furness Shipping and Agency as marine cargo superintendant and liner manager.

In 1974 he exchanged private enterprise for public service and was 13 years involved in vessel traffic- and portcontrol management at Pilot Maas, Europoort and the Harbour Co-ordination Centre respectively.

From 1987 – 1991 he was appointed as sector Harbourmaster of the Left Bank area of the Port of Rotterdam, after which he switched over from operational to policy management as Senior Policy Advisor, Nautical, Safety & Environmental affairs for the Maritime Development Department of the Division of Strategy and Communication of the Rotterdam Municipal Port Management

Capt. De Keyzer is representing the Port of Rotterdam in a large number of International, EU and National official bodies, working groups, committees and foundations and is also assigned as bunker co-ordinator for the RMPM. From 1996 – 2001 he was elected IBIA councillor, the International Bunker Industry Association. Currently he is Chairman of the annual International Bunker Conference, jointly organized by the Norwegian School of Management BI and the RMPM.

Port of Rotterdam

CHANCES FOR STRANGERS IN BALLASTWATER

By Capt. Cornelius de Keyzer

Generally speaking the transportmodality known as “water” has brought much benefit and joy to mankind. Unfortunately however, this is not the case with ballastwater from ships.
The distortion of local and regional ecosystems by thuswise conveyed alien invaders has become a serious and ongoing concern. The increasing current international attention for the problem is emphasizing the importance of the subject.

So far the focus has mainly been on a possible menace of exotics, predominantly from a scientific point of view. As a non-scientist I like to strike a different note or even two notes, namely as port authority and as a ship-operator.

IMO approach and developments through the Marine Environment Protection Committee

Annex I of IMO’s MEPC (draft) Ballastwater Management Code is, inter alia, mentioning practices for Deep Sea Ballastwater Exchange (BWE). Apart from that Port States shall:

(a) ensure that all ports having ship repair yards or tank cleaning facilities shall have adequate facilities available for the environmentally safe disposal of ballast tank sediments; and
(b) ensure that any port reception and / or treatment facilities for ballastwater are adequate, effective, practical, safe and environmentally sound and that they operate without causing undue delay.

On the one hand I must say that the IMO efforts to achieve a multilateral and harmonized solution are much more favourable than the unilateral approaches in already 14 different countries at present.
On the other hand I feel worried about the slow progress (MEPC 46 reports reaching the point where planning a diplomatic conference in 2003 should be considered) and the emphasis on Deep Sea BWE and possible treatment ashore. The latter is OK for sediments but certainly not for huge volumes of ballastwater together with investments and needed space ashore for - not causing undue delay - tankstorage provisions without a strict requirement for vessels to use the facilities.

Moreover both deballasting ashore and BWE are not considered to be an effective solution because a so called deballasted ship will never be 0% MT. Investigations from AQIS (Australian Quarantaine and Inspection Service) have shown that up to 5% of the original ballastwater may remain on board, containing up to 25% of the entire present organisms.
Apart from that it has been lined out that the different methods of BWE do not result in a complete removal of organisms (A.N. Cohen, San Francisco, 1997).

Just to compare volumes: (British numbers are used - source: Webster's New Lexicon Number Table)

-Annually some 10 – 12 Billion tons of ballastwater is transferred, only 1% left results in at least 100 Milliard tons.
-1% of the ballastwater capacity of a Double Hull VLCC (100.000 tons) still could result in 1000 tons.

Next to that, when taking containervessels into consideration, we have to face the fact that these ships are using ballastwater for proper trimming purposes and can carry a real "cocktail" for longer periods. Nowadays they are high speed vessels with a relative shorter interval between port calls. One and another is considered to be a real survival chance for "strangers".

Last but not least is the aspect of the burden on ships constructions during Deep Sea BWE, even under favourable weather conditions. Shear forces, bending moments, torsional forces, hull vibration, sloshing action, free surface effects, internal tankpressure, just to mention a few, are already threatening the safety of ships at present, specially with respect to (larger) bulkcarriers carrying high density cargoes.

Figures released by Intercargo show that during the 10-year period 1991 – 2000, a total of 134 bulkcarriers sank and 740 seafarers have gone down with their ships and apart from this mournful figure we should recognize that so far those vessels were not even subject to BWE procedures.

To a certain extent the MEPC recognized one and another, as reflected in MEPC document 44/4:

Safety related issues

2.10 Throughout the discussions within the Working Group two issues kept recurring:

- the need to emphasize throughout the text the paramount importance of maintaining the safety of vessels and of ship's crew
- the development of criteria for alternative treatment techniques and their performance standards

2.11 A number of experts considered these as being fundamental issues and that without such a basis it was difficult to develop draft provisions for a new convention and respective regulations. The Working Group agreed that the concerns regarding ship's safety should be set out in the Preambular text to the Convention.

Besides and on top of that I like to raise some questions:

- Do the three BWE methods, i.e. dilution, flow-through or sequential, have the same effect ?
- Is any of the three methods considered to be more favourable for the ship's construction ?
- Is it known whether a Deep Sea BWE area (at least 500 meters depth and at least 200 nautical miles from the nearest land) could or could not be effected by ecological distortion through ballastwater strangers disposed in such an area.?
- How strict and effective can BWE be controlled ?

With respect to the last question I can inform you that Intertanko circular 215 (November 1999) is already mentioning that there are a growing number of cases involving malpractice with BWE .
(An example was given in which a vessel was not considered to have carried out BWE, even though the master had reported otherwise. The port insisted that a specialist should board the vessel

and the ballast be treated with chlorine before discharge – the cost of which was levied upon the owner.)

Summarizing and taking all facts and figures into account my conclusion is that the real solution should strongly focus on ballastwater-treatment-methods ON BOARD.

At this very moment, in different parts of the world, a number of research projects have been initiated for ON BOARD ballastwater-treatment-methods. De-oxygenation, UV/US and ozonisation, Hydrogen peroxide, Thermal or Filtration techniques or a combination thereof are options. Also Gamma radiation might be a possibility. Hydrocyclone or cyclonic seperation are currently under assessment.

In this scope systems like the EVTN vortex centrifugal seperation technology with a second stage UV treatment or for larger flow rates a second stage chemical biocide treatment or the OptiMar Ballast Systems with an integrated cyclone / Microkill UV treatment are looking most promising. Lately a project with the MSI Microfugal Separator started aboard the USMA vessel Cape May in Baltimore.

Balancing the pros and cons and regarding the (dis)advantages of the three different options:

- Delivery and treatment ashore
- Deep Sea BWE and
- Treatment ON BOARD

I am convinced that the most effective and feasible approach and solution will be the last one

Port of
Rotterdam

Chances for Strangers in Ballastwater

Cornelius de Keyzer, Master Mariner

Senior Policy Advisor

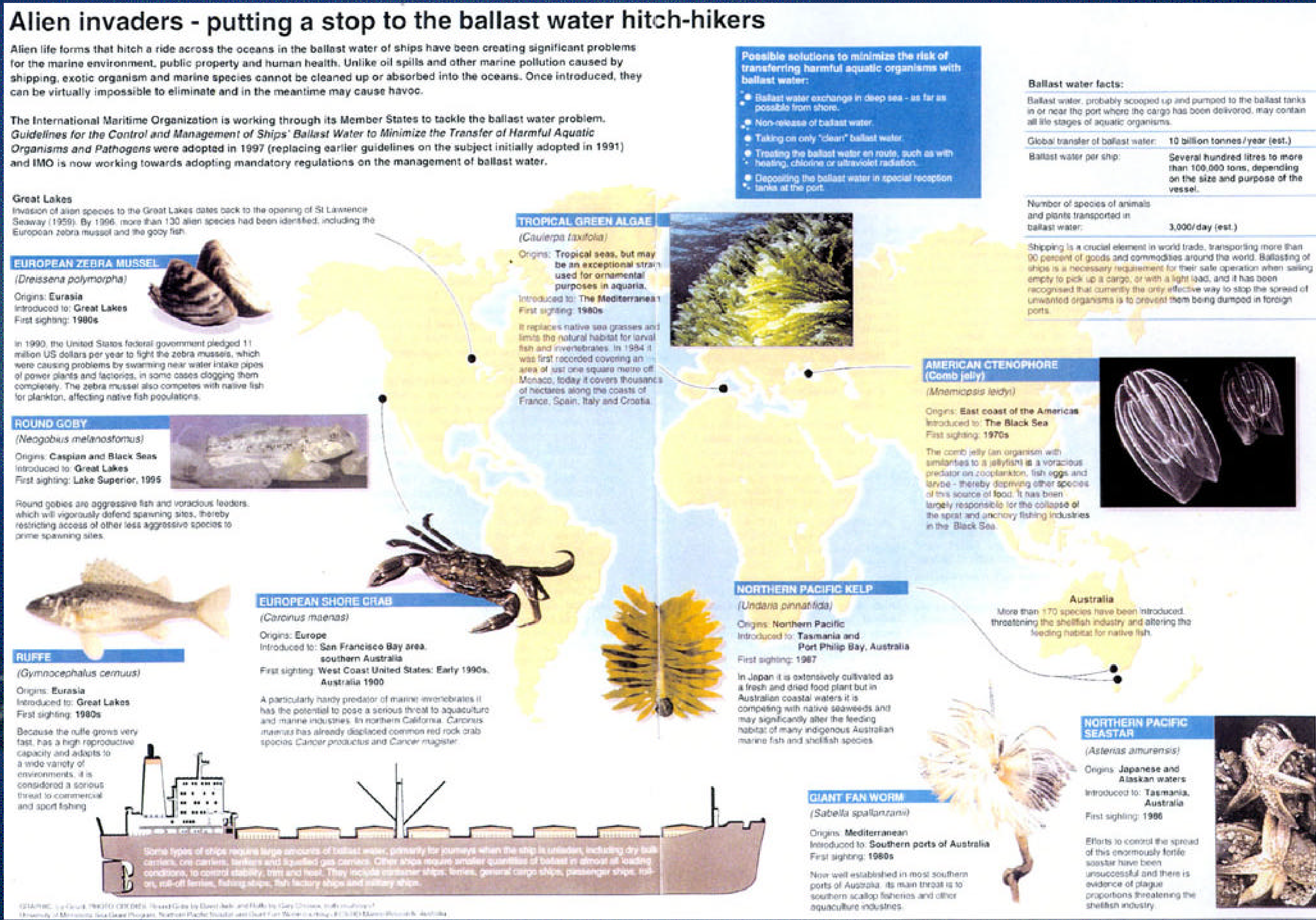
Nautical Environment and Safety

Strategy & Communication

Maritime Development

Rotterdam Municipal Port Management

Alien Invaders



Alien invaders - putting a stop to the ballast water hitch-hikers

Alien life forms that hitch a ride across the oceans in the ballast water of ships have been creating significant problems for the marine environment, public property and human health. Unlike oil spills and other marine pollution caused by shipping, exotic organism and marine species cannot be cleaned up or absorbed into the oceans. Once introduced, they can be virtually impossible to eliminate and in the meantime may cause havoc.

The International Maritime Organization is working through its Member States to tackle the ballast water problem. *Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens* were adopted in 1997 (replacing earlier guidelines on the subject initially adopted in 1991) and IMO is now working towards adopting mandatory regulations on the management of ballast water.

Possible solutions to minimize the risk of transferring harmful aquatic organisms with ballast water:

- Ballast water exchange in deep sea - as far as possible from shore.
- Non-release of ballast water.
- Taking on only "clean" ballast water.
- Treating the ballast water en route, such as with heating, chlorine or ultraviolet radiation.
- Depositing the ballast water in special reception tanks at the port.

Ballast water facts:

Ballast water, probably scooped up and pumped to the ballast tanks in or near the port where the cargo has been delivered, may contain all life stages of aquatic organisms.

Global transfer of ballast water:	**10 billion tonnes/year (est.)**
Ballast water per ship:	**Several hundred litres to more than 100,000 tons, depending on the size and purpose of the vessel.**
Number of species of animals and plants transported in ballast water:	**3,000/day (est.)**

Shipping is a crucial element in world trade, transporting more than 90 percent of goods and commodities around the world. Ballasting of ships is a necessary requirement for their safe operation when sailing empty to pick up a cargo, or with a light load, and it has been recognised that currently the only effective way to stop the spread of unwanted organisms is to prevent them being dumped in foreign ports.

Great Lakes

Invasion of alien species to the Great Lakes dates back to the opening of St Lawrence Seaway (1959). By 1996, more than 130 alien species had been identified, including the European zebra mussel and the goby fish.

EUROPEAN ZEBRA MUSSEL

(Dreissena polymorpha)

Origins: **Eurasia**
Introduced to: **Great Lakes**
First sighting: **1980s**

In 1990, the United States federal government pledged 11 million US dollars per year to fight the zebra mussels, which were causing problems by swarming near water intake pipes of power plants and factories, in some cases clogging them completely. The zebra mussel also competes with native fish for plankton, affecting native fish populations.

ROUND GOBY

(Neogobius melanostomus)

Origins: **Caspian and Black Seas**
Introduced to: **Great Lakes**
First sighting: **Lake Superior, 1995**

Round gobies are aggressive fish and voracious feeders, which will vigorously defend spawning sites, thereby restricting access of other less aggressive species to prime spawning sites.

RUFFE

(Gymnocephalus cernuus)

Origins: **Eurasia**
Introduced to: **Great Lakes**
First sighting: **1980s**

Because the ruffe grows very fast, has a high reproductive capacity and adapts to a wide variety of environments, it is considered a serious threat to commercial and sport fishing.

EUROPEAN SHORE CRAB

(Carcinus maenas)

Origins: **Europe**
Introduced to: **San Francisco Bay area, southern Australia**
First sighting: **West Coast United States: Early 1990s, Australia 1900**

A particularly hardy predator of marine invertebrates it has the potential to pose a serious threat to aquaculture and marine industries. In northern California, *Carcinus maenas* has already displaced common red rock crab species *Cancer productus* and *Cancer magister*.

TROPICAL GREEN ALGAE

(Caulerpa taxifolia)

Origins: **Tropical seas, but may be an exceptional strain used for ornamental purposes in aquaria.**
Introduced to: **The Mediterranean**
First sighting: **1980s**

It replaces native sea grasses and limits the natural habitat for larval fish and invertebrates. In 1984 it was first recorded covering an area of just one square metre off Monaco, today it covers thousands of hectares along the coasts of France, Spain, Italy and Croatia.

AMERICAN CTENOPHORE (Comb jelly)

(Mnemiopsis leidyi)

Origins: **East coast of the Americas**
Introduced to: **The Black Sea**
First sighting: **1970s**

The comb jelly (an organism with similarities to a jellyfish) is a voracious predator on zooplankton, fish eggs and larvae - thereby depriving other species of this source of food. It has been largely responsible for the collapse of the sprat and anchovy fishing industries in the Black Sea.

NORTHERN PACIFIC KELP

(Undaria pinnatifida)

Origins: **Northern Pacific**
Introduced to: **Tasmania and Port Philip Bay, Australia**
First sighting: **1987**

In Japan it is extensively cultivated as a fresh and dried food plant but in Australian coastal waters it is competing with native seaweeds and may significantly alter the feeding habitat of many indigenous Australian marine fish and shellfish species.

Australia

More than 170 species have been introduced, threatening the shellfish industry and altering the feeding habitat for native fish.

GIANT FAN WORM

(Sabella spallanzanii)

Origins: **Mediterranean**
Introduced to: **Southern ports of Australia**
First sighting: **1980s**

Now well established in most southern ports of Australia, its main threat is to southern scallop fisheries and other aquaculture industries.

NORTHERN PACIFIC SEASTAR

(Asterias amurensis)

Origins: **Japanese and Alaskan waters**
Introduced to: **Tasmania, Australia**
First sighting: **1986**

Efforts to control the spread of this enormously fertile seastar have been unsuccessful and there is evidence of plague proportions threatening the shellfish industry.

Some types of ships require large amounts of ballast water, primarily for journeys when the ship is unladen, including dry bulk carriers, ore carriers, tankers and liquefied gas carriers. Other ships require smaller quantities of ballast in almost all loading conditions, to control stability, trim and heel. They include container ships, ferries, general cargo ships, passenger ships, roll-on, roll-off ferries, fishing ships, fish factory ships and military ships.

With acknowledgement to IMO news

200105PP-034

American Ctenophore (Comb Jelly)

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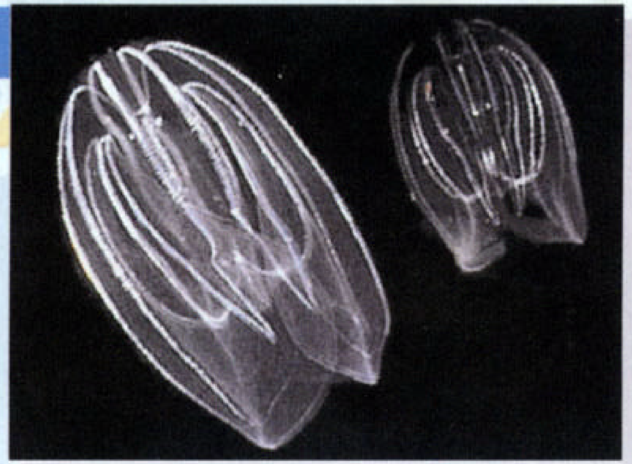

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European Zebra Mussel

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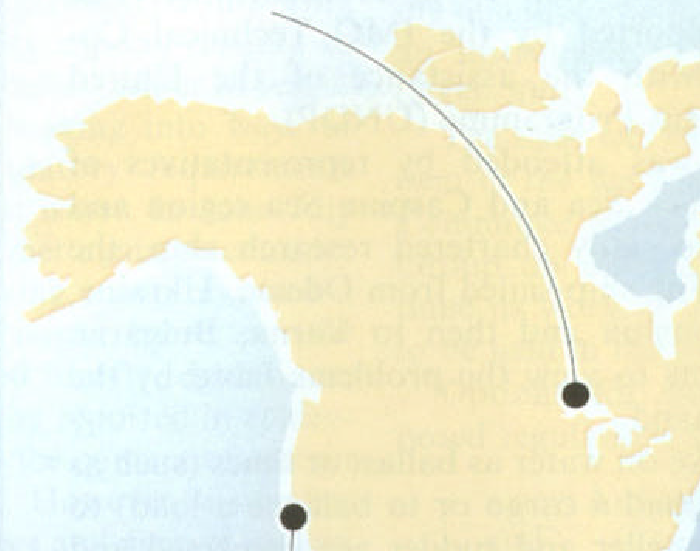
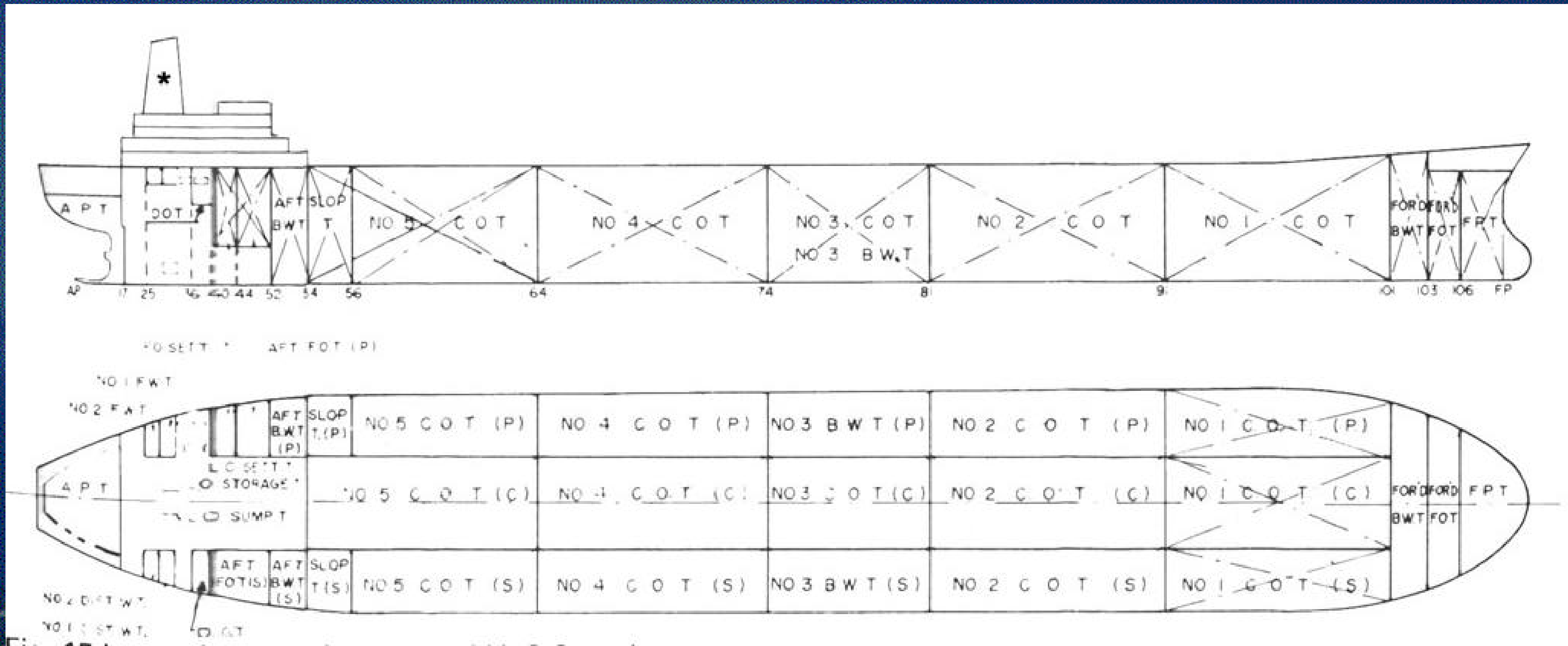


With acknowledgement to IMO news

Ballastwatercapacities in % of DWT

ULCC > 300.000	30%
VLCC > 200.000	30%
Suezmax Tankers (120.000 - 200.000)	30%
Aframax Tankers (80.000 - 120.000)	30%
Older and/or smaller tankers	20%
Chemical tankers	20%
LNG/LPG tankers	25 - 30%
OBO's and Ore/oil tankers	30%
Northsea Shuttletankers (60-120.000)	up to 40 - 50%
Bulkcarriers Capesize	20%
Bulkcarriers Panamax (60-80.000)	20%
Bulkcarriers Handysize (20-60.000)	20%
General Cargo	10 - 15%
RoRo's	20 - 25%
Vehicle carriers	20 - 25%
LASH vessels	30%
Containervessels	10 - 15%
Post Panamax containervessels	30%

Single Hull Tanker



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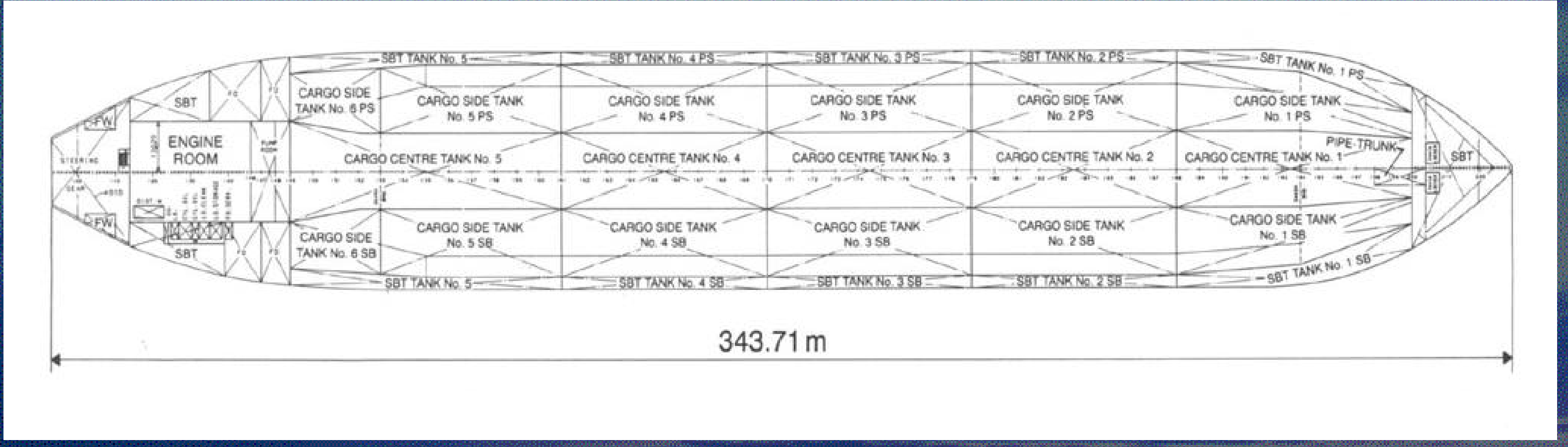
Double Hull Tanker



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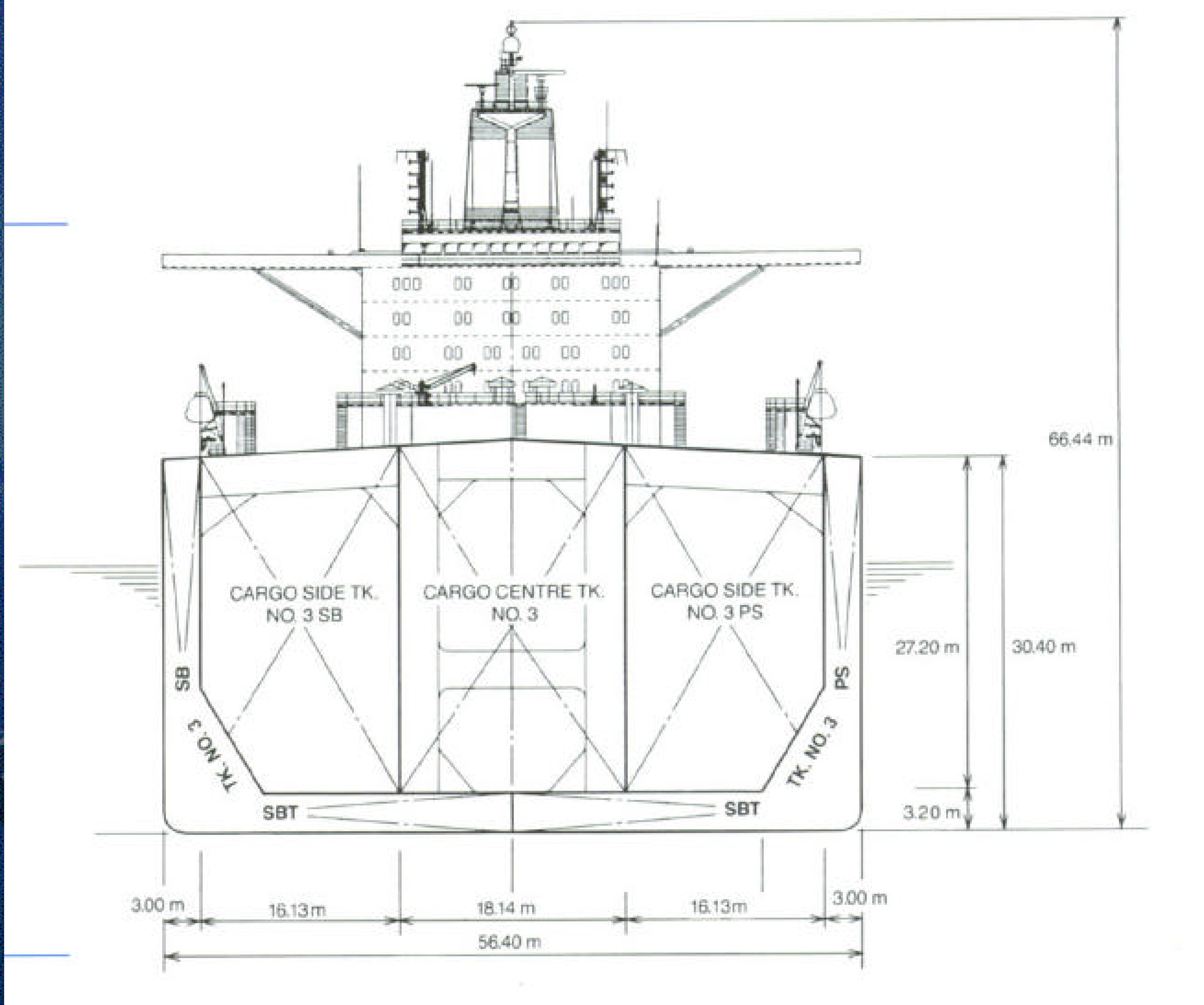
Double Hull Tanker



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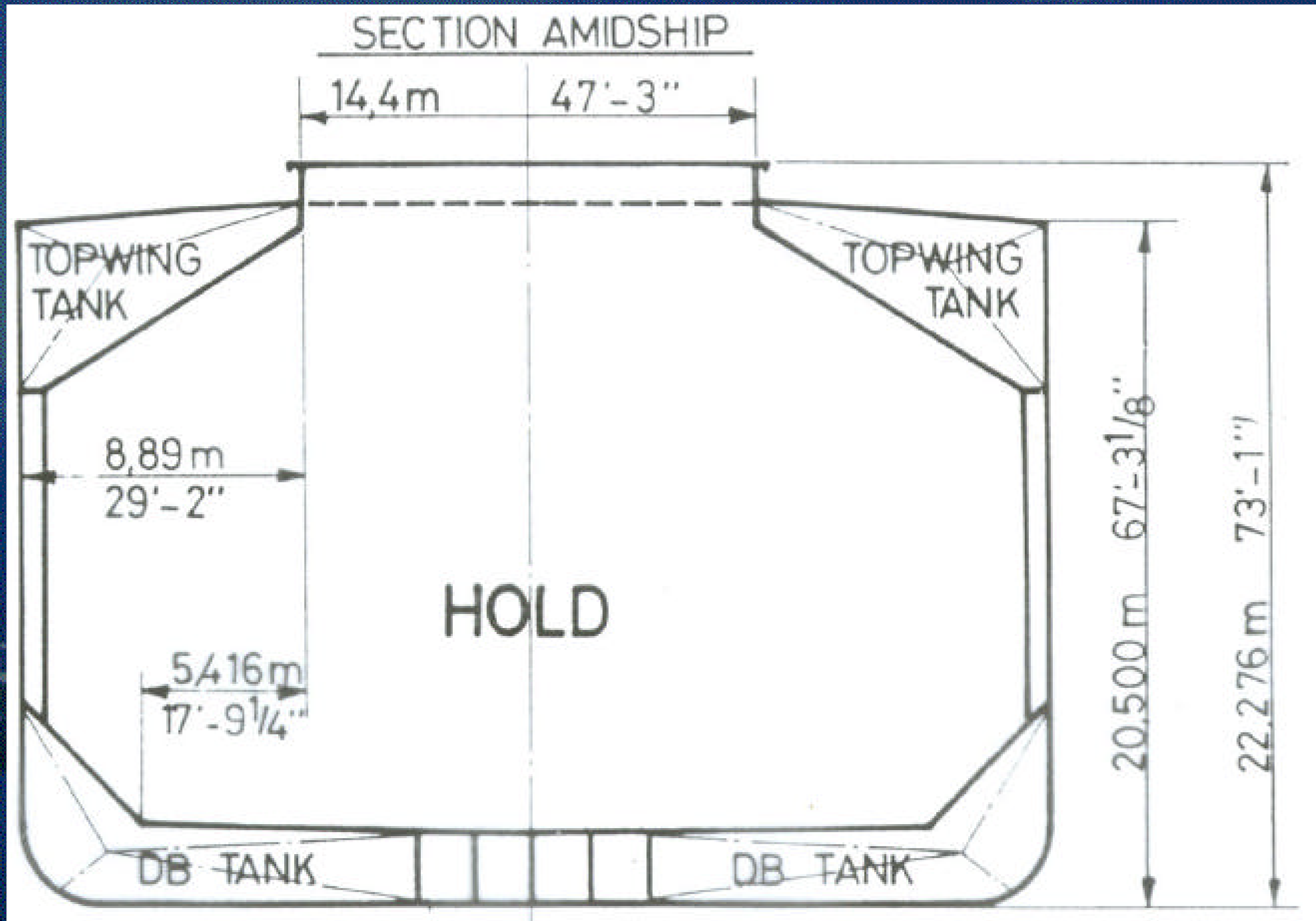
Bulkcarrier



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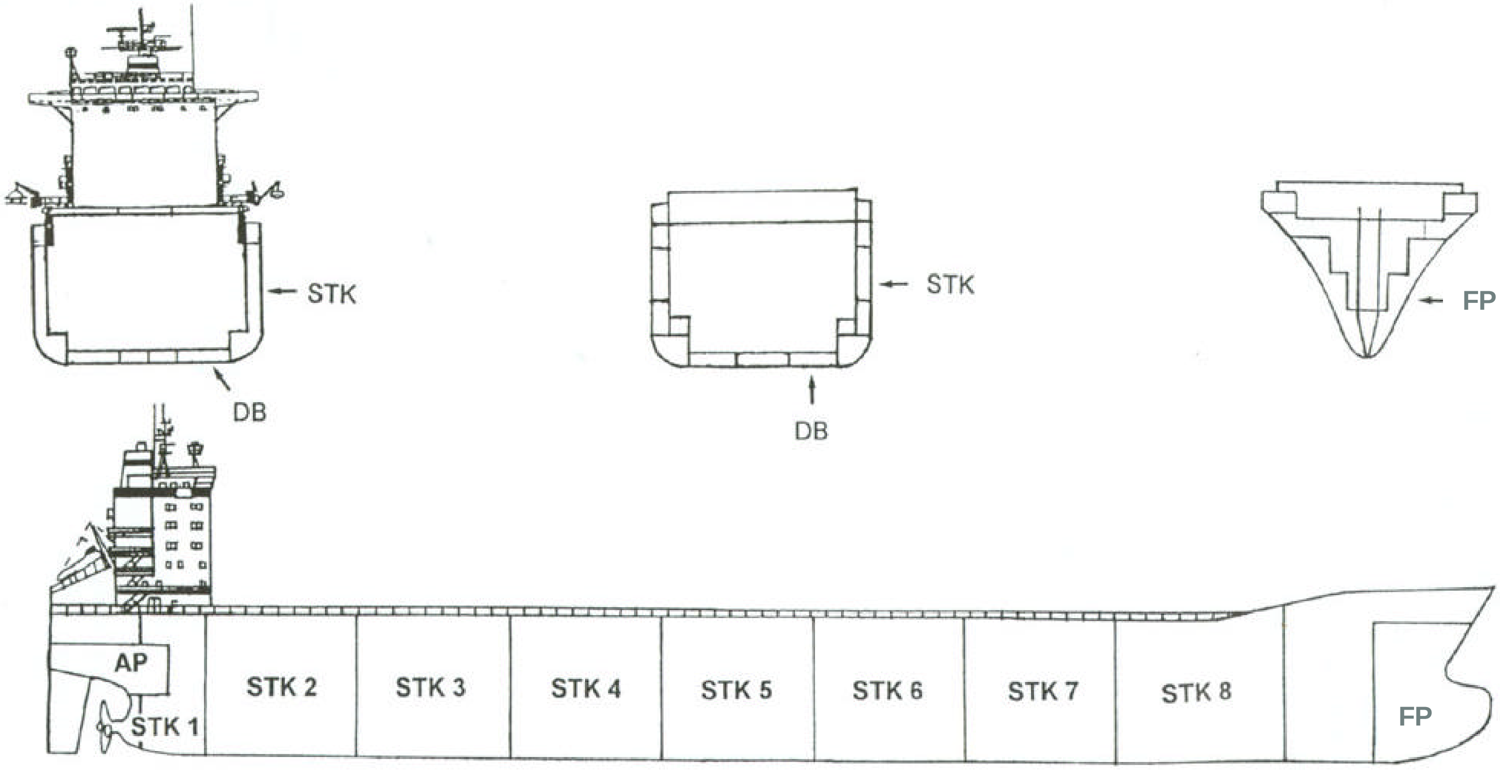
UCC



Profile view of a modern container vessel showing the position of ballast water tanks (AP = aft peak tank, FP = fore peak tank, STK = side tanks and DB = double bottom tanks).

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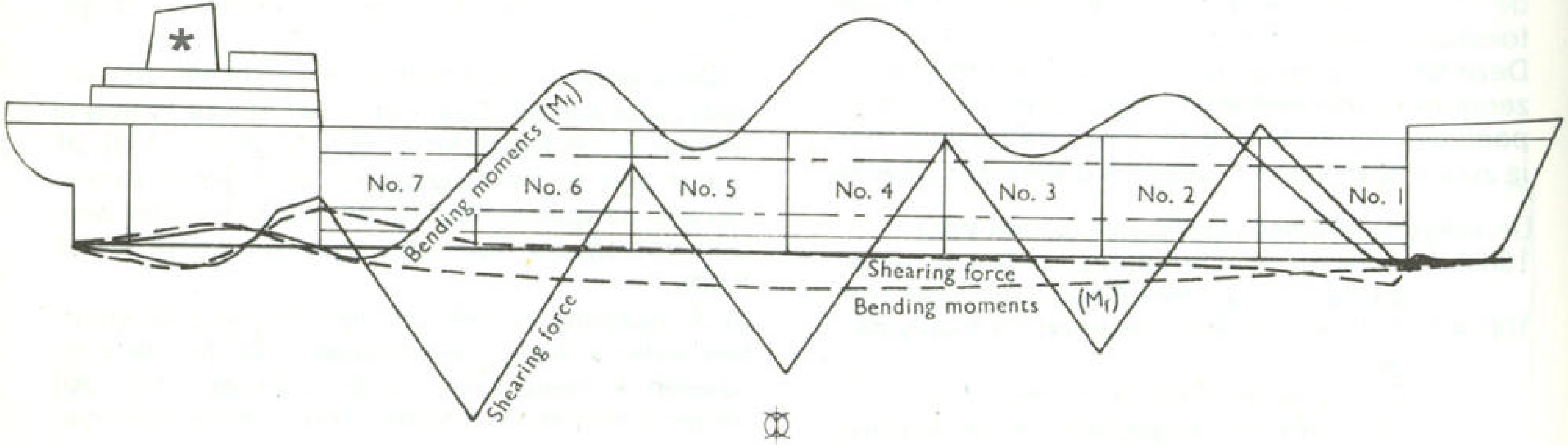

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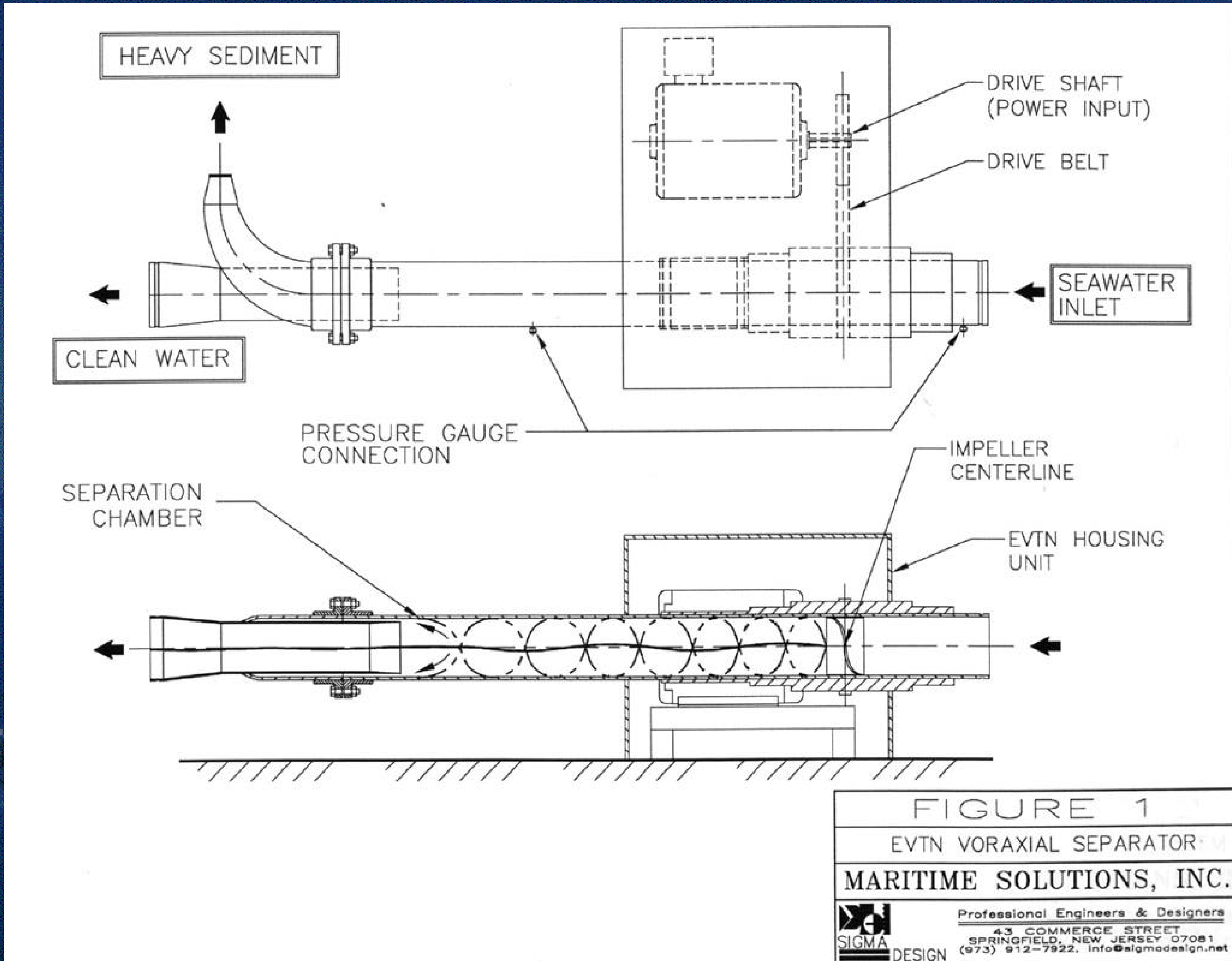
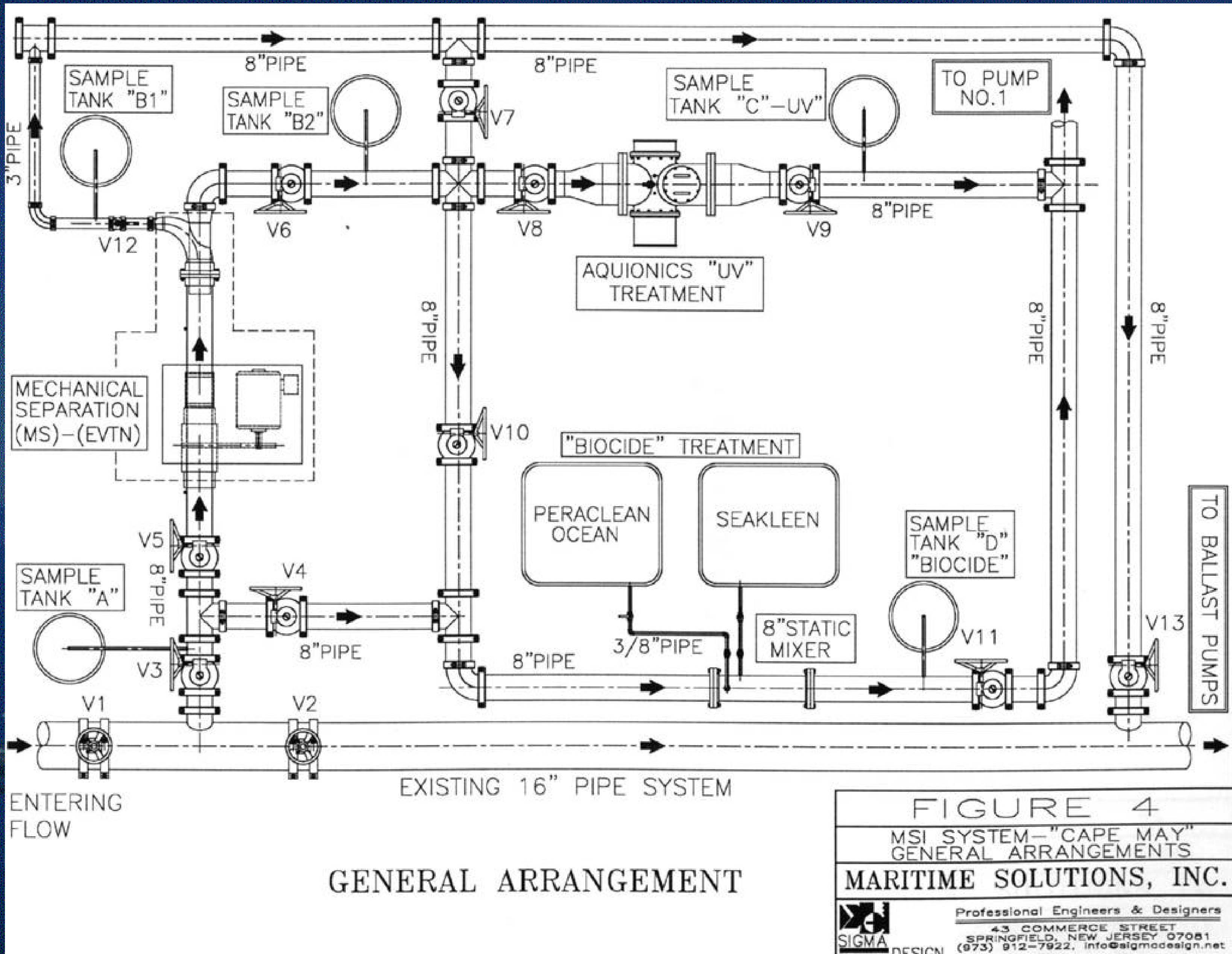

HEAVY SEDIMENT
DRIVE SHAFT (POWER INPUT)
DRIVE BELT
SEAWATER INLET
CLEAN WATER
PRESSURE GAUGE CONNECTION
IMPELLER CENTERLINE
SEPARATION CHAMBER
EVTN HOUSING UNIT
FIGURE 1
EVTN VORAXIAL SEPARATOR
MARITIME SOLUTIONS, INC.
Professional Engineers & Designers
43 COMMERCE STREET
SPRINGFIELD, NEW JERSEY 07081
(973) 912-7922, info@sigmadesign.net
SIGMA DESIGN



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CURRICULUM VITAE

Steve Raaymakers

Citizenship: Australian.

Tertiary Education:

MSc Coastal & Ocean Policy (currently underway) – Plymouth Univ., UK

BSc Marine Science (1987) – James Cook Univ., Australia.

Employment History:

March 2000 – present: ***Technical Adviser***, Marine Environment Division, International Maritime Organization, London

- Second in charge of the Programme Coordinaton Unit for the Global Ballast Water Management Programme.

Jan 98 – March 2000: ***Marine Adviser,*** South Pacific Regional Environment Programme (SPREP), South Pacific Region.

- Worked for SPREP, an inter-governmental regional organisation, to develop and manage PACPOL, a comprehensive programme to implement IMO marine pollution conventions in 22 Pacific island countries.

Nov 93 – Jan 98: ***Environmental Manager***, Queensland Ports Corporation, Australia.

- Worked for Queensland State Government to develop and manage a comprehensive environmental programme for 12 industrial ports in Queensland, Australia.

Nov 89 – Nov 93: ***Project Manager***, Research and Monitoring, Great Barrier Reef Authority, Australia.

- Worked for Australian Federal Government on programmes to protect the Great Barrier Reef from shipping and port impacts, Scientific Support Coordinator under REEFPLAN, the marine pollution contingency plan for the Great Barrier Reef.

March 89 – Nov 89: ***Sail Trainer*** on square rigged tall ship "Eye of the Wind".

- Sail training and adventure tourism cruises through the western Pacific.

Jan 87 – Nov 89: ***Diving Instructor*** and ***Marine Consultant***, Great Barrier Reef, Australia.

- Diving operations and marine consultancy services, Great Barrier Reef.

ABSTRACT

Steve Raaymakers
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Global Ballast Water Management Programme, IMO

"Latest Developments on International Ballast water Management Initiatives at IMO"

The introduction of harmful aquatic organisms and pathogens to new environments, including via ships' ballast water, has been identified as one of the four greatest threats to the world's oceans. It is estimated that a foreign marine species is introduced to a new environment somewhere in the world every nine weeks. Human health, ecological and economic impacts can be severe.

The International Maritime Organization has been working on this issue for over ten years. The Marine Environment Protection Committee formed a Ballast Water Working Group in 1990 and in 1997, the first set of guidelines elaborated in 1993 were improved and adopted as assembly resolution A.868(20).

While the 1997 guidelines have provided a sound basis for the management and control of ballast water, the MEPC has also been actively working on the creation of an international convention for the regulation of ballast water. The development of this convention is now reaching the point where it appears that a diplomatic conference to adopt it could be held within three years, which would be a major breakthrough in dealing with this problem.

In anticipation of the new convention, IMO, with funding provided by the Global Environment Facility (GEF), has initiated the Global Ballast Water Management Programme (GloBallast), to assist developing countries to implement the existing IMO guidelines and to prepare for the new ballast water convention.

Under both the existing IMO guidelines and the new convention, ballast water exchange at sea remains the main management measure for reducing the risk of transfer of harmful aquatic organisms. It is widely recognized that ballast water exchange has many limitations, including serious safety concerns that limit its applicability, and the fact that translocation of species can still occur even when a vessel has undertaken full ballast exchange. It is therefore extremely important that alternative, more effective ballast water treatment methods are developed as soon as possible. To facilitate the development of alternative methods, it is vital that internationally agreed and approved standards for the evaluation and approval of new ballast water treatment systems are developed and agreed as soon as possible.

Ballast water transfers and invasive marine species are one of the most serious environmental challenges facing the global shipping industry. The IMO Secretariat is working to ensure the development and effective implementation of a uniform, standardized, global ballast water management regime. This paper outlines IMO's activities in this area.

Latest Developments in
International Ballast Water Management Initiatives at IMO

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1. The Problem

It is estimated that 10 to 12 billion tonnes of ballast water are carried around the world by ships each year. While ballast water is essential to the safe operation of ships, it also poses a serious environmental threat, in that around 4,500 species of marine microbes, plants and animals may be carried globally in ballast water at any one time. When discharged into new environments, these species may become invasive and severely disrupt the native ecology and have serious impacts on the economy and human health. It is estimated that a foreign marine species is introduced to a new environment somewhere in the world every nine weeks. The global economic impacts of invasive marine species have not been quantified but are likely to be in the order of tens of billions of US dollars a year.

The introduction of harmful aquatic organisms and pathogens to new environments, including via ships' ballast water, has been identified as one of the four greatest threats to the world's oceans. The other three are land-based sources of marine pollution, over-exploitation of living marine resources and physical alteration and destruction of coastal and marine habitats.

The transfer of invasive marine species in ballast water is perhaps the biggest environmental challenge facing the global shipping industry this century.

2. The IMO

The International Maritime Organization (IMO) is the specialised agency of the United Nations that develops and administers the international regulatory regime for maritime safety and the prevention of pollution from ships. IMO's role may be summarised by the catch-phrases 'Safer Ships – Cleaner Oceans' and 'Protecting Seafarers from the Sea – Protecting the Sea from Seafarers.'

IMO provides an international forum through which member-countries negotiate, develop, agree, adopt, ratify, enter into force and administer international Conventions and other legal instruments on maritime safety and marine pollution. This is achieved through the work of sector-specific committees, comprising member countries and observer organisations, such as the Maritime Safety Committee (MSC) and the Marine Environment Protection Committee (MEPC), and various working groups established under these committees. The shipping industry is a major stakeholder in all IMO Committees. The Conventions are implemented at the national level through national administrations and legislation.

In addition to its Convention Secretariat role, IMO also provides technical assistance and cooperation to developing countries to assist in the implementation of its Conventions. More information about IMO can be found at www.imo.org.

3. The IMO Response

IMO has responded to the ballast water 'problem' by:

- forming a Ballast Water Working Group under its Marine Environment Protection Committee (MEPC),

- adopting *Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens* (Assembly Resolution A.868(20)), and

- developing a new international legal instrument (Convention) on ballast water management, to be considered by an IMO Diplomatic Conference in 2003.

Until the new Ballast Water Convention is adopted, the IMO Guidelines (A.868(20)) should be used by governments and the shipping industry as the international standard for ballast water management. They can be downloaded from http://globalalst.imo.org.

4. The New Convention

The new Ballast Water Convention will provide a uniform, standardized, global ballast water management regime, and adopts a 'Two Tier' approach. Tier One is the base level requirement that would apply to all ships, including the mandatory carriage of a Ballast Water & Sediment Management Plan, Ballast Water Record Book and a requirement to carry out certain ballast water management procedures after a phase in period. Recognition is given that procedures may differ for new ships.

Tier Two would apply only in prescribed ballast water management areas. However, further work is required to determine the extent of the proposed second tier requirements, including how the UN Convention on the Law of the Sea (UNCLOS) might apply.

It is anticipated that the Convention will be adopted by an IMO Diplomatic Conference in late 2003. The draft text of the Convention can be found on http://globallast.imo.org.

5. Unilateral Responses

Of great concern to both IMO and the global shipping industry is that in the absence of a single, uniform, international legal instrument for the regulation of ballast water management, individual jurisdictions at the national, provincial and local level are proceeding with implementing their own regulatory regimes.

The danger of this fragmented, patchwork approach is that differences may arise between each regulatory system. Because shipping is an international industry, with ships passing across jurisdictional lines in order to conduct trade, differences between regulatory systems can create extreme compliance difficulties and significant cost implications for shipping.

Despite these problems, many jurisdictions, which are most concerned about protecting their coastal and marine resources from the dangers of invasive marine species, are implementing their own ballast water management legislation and regulations.

The web site of the International Association of Independent Tanker Owners (INTERTANKO) provides profiles of national ballast water legislation (www.intertanko.com/tankerfacts/environmental/ballast/ballastreq.htm.)

These unilateral regulatory responses raise a number of significant concerns, including discrepancies and duplication between different regimes that apply to the same international industry; the apparent arbitrary basis for some of the requirements; real, practical impediments to achieving some of the requirements and the granting of maritime regulatory powers to agencies with extremely limited experience in dealing with shipping issues.

The prerogative of coastal states to protect their coastal and marine resources from shipping impacts must be maintained. However, a piece-meal, disjointed approach is counter-productive when dealing with a trans-boundary, global industry such as shipping. The vital need for a uniform and effective international law on ballast water could not be greater than it is right now.

6. Ballast Exchange at Sea & Alternative Treatment Methods

Under both the existing IMO Guidelines and the new Convention, ballast water exchange at sea remains the main, albeit interim, management measure for reducing the risk of transfer of harmful aquatic organisms. It is widely recognized that ballast water exchange has many limitations. These include:

- It may be unsafe for some ships in certain weather conditions, threatening the stability and/or the structural integrity of the ship.

- Some ships do not have plumbing, ballast tank arrangement and/or pumping capacity suitable for ballast exchange.

- Some voyages are too short to allow complete ballast exchange.

- While it is theoretically possible to achieve up to 99% + volumetric exchange of ballast water, the biological effectiveness may vary widely. Several studies indicate that species diversity and abundance can actually increase in ballast tanks after exchange. Even when carried out in full, harmful species may still be transferred.

- Some oceanic species taken on during ballast exchange may survive and establish in coastal waters, and vice versa.

The race is therefore on to find alternative, more effective ballast water treatment methods. IMO has identified more than 40 different projects around the world, either completed or underway, aimed at developing potential new systems. R&D groups are spurred on by the prospect of a potential US$2 billion market for an effective ballast water treatment system that receives international approval. Technologies being researched include:

- filtration and physical separation,
- chemicals,
- ultra-violet light,
- ozone,
- heat,
- de-oxygenation,
- electro-ionisation,
- gas super-saturation,
- various combinations of the above, and
- others.

The R&D projects are based in countries as far-flung as Australia, Brasil, Canada, China, Germany, Japan, New Zealand, Norway, Poland, Singapore, the UK and the USA. They comprise government programmes, private initiatives, private-public consortiums, local efforts, national programmes and international alliances.

One of the difficulties faced by this diverse global R&D effort, was the lack of effective lines of communication between these groups and with governments and the shipping industry. It has been difficult for any party to gain an up-to-date picture of the latest 'state-of-the-art' in ballast water treatment R&D. The shipping industry, the ultimate end-user of this effort, is being bombarded with offers from vendors of so-called 'solve-all' ballast water treatment systems, without any formal international system for their independent evaluation and approval.

To help address this situation, the GloBallast programme at IMO (see below) has produced the *Ballast Water Treatment R&D Directory*, and convened the 1st International Ballast Water Treatment *R&D Symposium* in March 2001.

Twenty six papers were presented at the symposium by the world's leading ballast water treatment experts, covering all of the technologies referred to above and updating the latest results from the major R&D projects. The symposium attracted nearly 200 participants. The general picture that emerged from the symposium was as follows:

- All of the various technologies are currently at a very early stage of development and significant further research is required.

- It is likely to be some years before a new ballast water treatment system is developed, proven effective, approved and accepted for operational use. Ballast water exchange will therefore remain a primary method for some time yet, despite its limitations.

- It appears that any new ballast water treatment system will involve a combination of technologies, for example primary filtration or physical separation followed by a secondary biocidal treatment.

- The current global budget for ballast water treatment R&D (about US$10 million) is insignificant compared to the global costs of marine introductions (likely to be at least in the tens of billions of US$).

- There is a desperate need to develop and implement international standards and procedures for the evaluation and approval of new ballast water treatment systems.

Abstracts of papers presented are currently available on the GloBallast web site http://globallast.imo.org, on the page titled 'Ballast Water Treatment'. The full proceedings are currently being prepared and will be available in the near future.

The symposium was hailed as a major success and participants requested that it become a regular event held every one to two years. IMO/GloBallast is currently exploring options for this.

7. The Need for Standards

In response to the need to develop and implement international standards and procedures for the evaluation and approval of new ballast water treatment systems, the R&D symposium was immediately followed by the 1st International Ballast Water Treatment *Standards Workshop* from 28 to 30 March 2001.

The shipping industry has made repeated calls for international standards to be developed and adopted. This will provide the industry with a clear target to aim for and encourage innovation.

The standards workshop was by invitation only, in order to ensure a manageable process and that a meaningful result would be achieved. The invitation list ensured a broad representation from the shipping industry, water treatment industry, marine science community, governments and environmental organisations. The total number of participants was around 70.

The workshop was tasked with brainstorming the development of possible ballast water treatment standards, and in particular a *biological effectiveness* standard (*biological effectiveness* meaning removing, killing or rendering inactive organisms in ballast water).

The workshop unanimously agreed five Primary Criteria that any new treatment systems should meet and 10 Fundamental Principles that should be applied in developing biological effectiveness standards, as follows:

Primary Criteria for New Ballast Water Treatment Technologies

Any new alternative ballast water treatment technologies should meet the five following Primary Criteria:

1. It must be safe (in terms of the ship and its crew).

2. It must be environmentally acceptable (not causing more or greater environmental impacts than it solves).

3. It must be practicable (compatible with ship design and operations).

4. It must be cost effective (economical).

5. It must be biologically effective (in terms of removing, killing or otherwise rendering inactive aquatic organisms and pathogens found in ballast water).

Fundamental Principles for Biological Effectiveness Standards

The following Fundamental Principles should be applied in developing possible biological effectiveness standards for new alternative ballast water treatment technologies:

1. The three currently generally accepted methods of ballast water exchange at sea (empty/refill, flow-through and dilution) remain the best currently available methods of minimising the transfer of harmful aquatic organisms and pathogens. It appears likely that they will remain the best available methods for the foreseeable future.

2. While recognising point 1 above, it is not appropriate to use equivalency to ballast water exchange as an effectiveness standard for evaluating and approving/accepting *new* ballast water treatment technologies, as the relationship between volumetric exchange and real biological effectiveness achieved by ballast water exchange is not defined. This relationship cannot be established without extremely expensive empirical testing.

3. The standard should be based on the concept of reducing/minimising the risk of biological introductions through ballast water, recognising that 100% biological effectiveness of ballast water treatment is not achievable for all aquatic organisms and pathogens with best currently available technology.

4. It should be a Performance Standard as opposed to a Process Standard or a Management Standard.

5. The type approval test should be based on water quality.

6. A single, global, uniform, primary biological effectiveness standard should be developed, although it may be appropriate to develop additional standards for specific situations (e.g. different geographical regions, different taxonomic groups, different vessels), based on a risk assessment approach.

7. Flexibility must be retained to allow the standard(s) to be revised and updated over time as technology develops, knowledge increases and improved ballast water treatment biological effectiveness becomes possible.

8. It would be useful for relevant bodies to develop a list of global species of concern, to aid in refining such standards.

9. It may be appropriate in certain circumstances to use surrogate measurements in evaluating ballast water treatment effectiveness, but these should be calibrated against actual organisms.

10. The applicability of the standard(s) to new versus existing ships needs to be resolved.

The workshop also proposed two possible options for such a standard, one representing a majority view and the other a dissenting view.

The workshop report was submitted to the Ballast Water Working Group of the 46th meeting of MEPC held from 23 to 27 April. MEPC welcomed the report and agreed to use it as the basis from which to develop standards for use in the new international convention on ballast water. A correspondence group coordinated by the USA has been tasked to do this, and will report to MEPC 47 in March 2002.

The workshop report is available on the GloBallast web site, on the page titled 'Ballast Water Treatment'. It should be noted that the treatment standards described in it are for discussion purposes only. The formal, official process of MEPC is where a final standard will be developed and agreed by member countries.

8. The GloBallast Programme

In anticipation of adoption of the new Ballast Water Convention, IMO has also joined forces with the Global Environment Facility (GEF) and the United Nations Development

Programme (UNDP) to implement the Global Ballast Water Management Programme (GloBallast). The Development Objectives of this technical cooperation programme are to assist developing countries to:

- reduce the transfer of harmful aquatic organisms and pathogens in ships' ballast water,
- implement existing IMO ballast water management Guidelines, and
- prepare for the implementation of a new international Ballast Water Convention.

The programme is working to achieve these objectives through a three-person Programme Coordination Unit (PCU) at IMO in London and six initial Demonstration Sites, located in six Pilot Countries. These represent the main developing regions of the world, as follows:

Table 1: *GloBallast Phase I Demonstration Sites*

Demonstration Site	Pilot Country	Region Represented
Dalian	China	Asia/Pacific
Khark Island	IR Iran	Arab/Persian Gulf
Odessa	Ukraine	Eastern Europe
Mumbai	India	South Asia
Saldanha	South Africa	Africa
Sepetiba	Brasil	South America

Activities being carried out at these sites focus on institutional strengthening and capacity building and include:

- Establishment of National Lead Agencies and Focal Points for ballast water issues.
- Employment of Country Focal Point Assistants.
- Formation of cross-sectoral/inter-ministerial Country Task Forces.
- Communication and awareness raising activities.
- Ballast water risk assessments.
- Port biota baseline surveys.
- Ballast water sampling.
- Training in implementation of the IMO Ballast Water Guidelines.
- Assistance with national ballast water legislation and regulations.

- Training and technical assistance with compliance monitoring and enforcement.

- Assistance with developing national ballast water management strategies and action plans.

- Assistance with developing self-financing and resourcing mechanisms.

- Initiation of cooperative regional arrangements for ballast water management.

As the programme develops, it is intended that successes at the initial Demonstration Sites will be replicated through regional programmes.

Phase I has a budget of US$10.2 million, representing US$7.6 million from GEF and US$2.4 million from the pilot countries (approx).

GloBallast was commenced in March 2000, with a three-year timeframe, until March 2003. As we approach the mid-point of the programme, significant progress has been made by the GloBallast Programme Coordination Unit (PCU) at IMO in London and each of the six Pilot Countries, in achieving the programme's objectives and workplans.

To date, an unprecedented momentum of concerted international action has been precipitated by the GloBallast programme. There is an overwhelming demand from developing countries for ongoing programmatic support for regional replication and technical assistance activities. A number of countries and regions have expressed strong interest in joining the programme, including the Mediterranean region, the Pacific Islands Region, the Caspian Sea region, the Eastern Baltic countries, several South American countries and several African countries. This interest is increasing almost daily. Strategic planning is therefore now underway for GloBallast Phase II, to commence in April 2003. Phase II will have a greater focus on promoting regional cooperation.

9. Conclusions

- The introduction of harmful aquatic organisms and pathogens to new environments, including via ships' ballast water, has been identified as one of the four greatest threats to the world's oceans.

- IMO as the specialised agency of the UN responsible for maritime matters and the agency through which all ballast water and hull fouling issues should be addressed at the global scale.

- It is of paramount importance that the ballast water issue is addressed through a standardised global system administered by IMO, and that unilateral responses by individual jurisdictions can have major negative effects on the overall global attempts to address this problem effectively, and must be avoided.

- The international shipping industry is the key stakeholder in the ballast water issue, there is a vital need for their full involvement, and IMO has in place extremely well developed mechanisms for the involvement of the shipping industry.

- IMO seeks to avoid duplication of effort in this area by other agencies and to ensure coordination, cooperation and collaboration of all efforts in relation to invasive marine species and ballast water.

- Ballast water transfers and invasive marine species are one of the most serious environmental challenges facing the global shipping industry. The IMO Secretariat remains committed to providing all the assistance necessary to assure the development and effective implementation of a uniform, standardized, global ballast water management regime.

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International Consulting S.P.R.L.

Maritime Conferences

• The Maritime Environment •

”Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports”

Session 2

Waste Water and Sewage Treatment Technologies

Session Chairman: (13th Sept)
John KLie
Zenon Environmental Inc, CA

Session Chairman: (14th Sept)
Valenttijn Korteling
PROMAC B.V., NL

CURRICULUM VITAE

Speaker Mr. Klaas Jan Bolt

I should like to introduce the next speaker which is Mr. Klaas Jan Bolt from the Ministry of Transport and Public Works, the Netherlands.

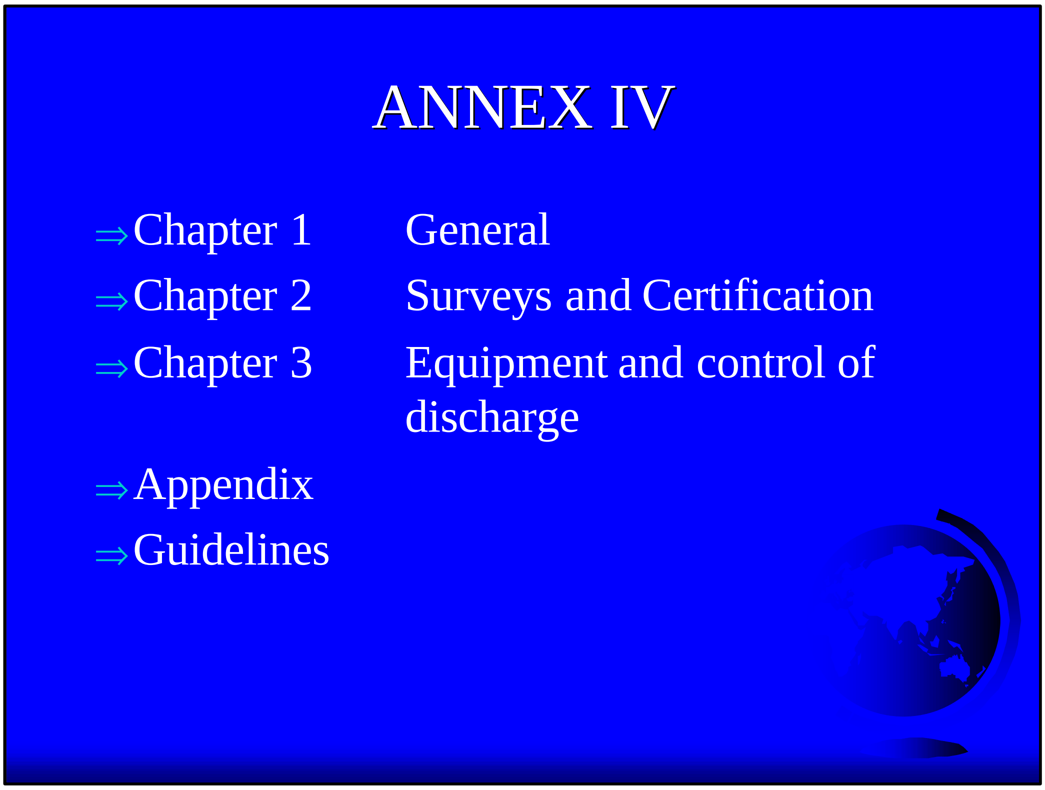
Mr. Klaas Jan Bolt graduated from the Nautical College as Master Mariner and served almost 20 years in the Merchant Navy as Deck Officer and Master on board different types of ships.

He than served as North Sea Pilot in the English Channel, the North Sea and the Baltic Sea.

After some years as a Professor at the Nautical College he became a civil servant working for the NL Ministry of Transport and Public works. His specialisation is the protection of the maritime environment in relation to shipping. He is active also in international maritime fields, both within the IMO and the European Union.

SHEET 1

Short history Annex IV – developed beginning 70 ties – developed because sewage considered a problem in those days – dealing with grey and black water – conditions for entering inot force same as otehr annexes – Annex IV is an optional annex like III and V – optional annexes in principle another priority than annex I and II – judgement for annex IV questionable -



SHEET 2

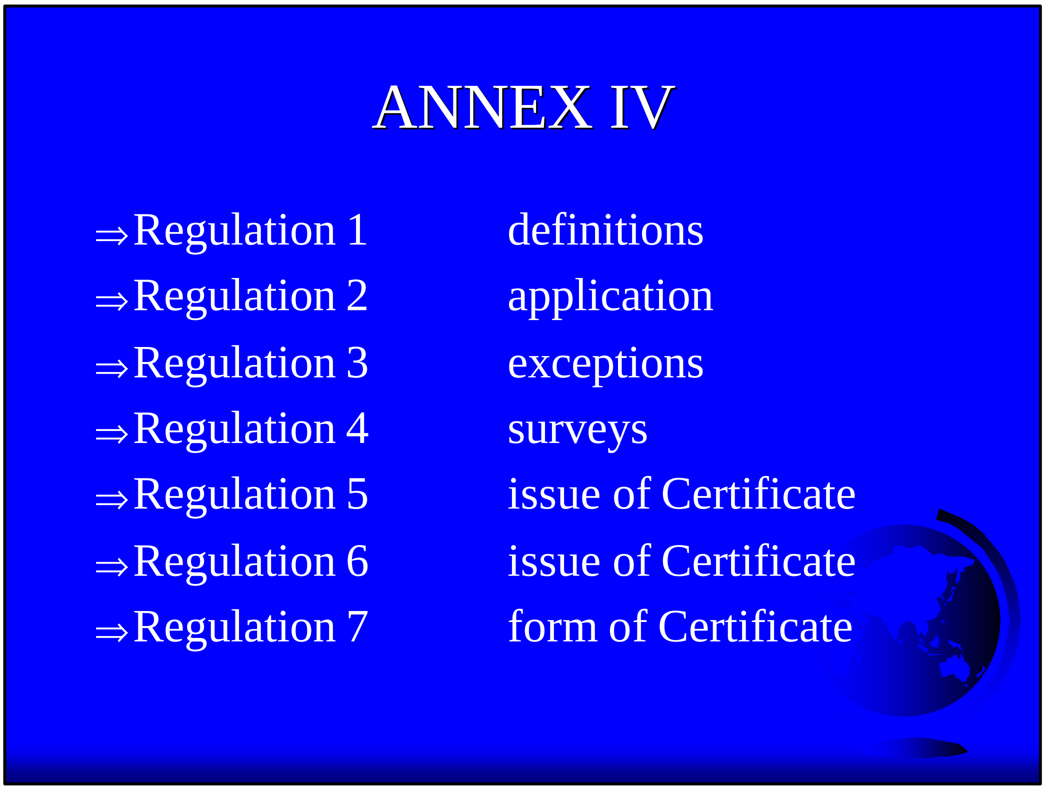
odes are non-binding instruments

sometimes reference in convention to relevant codes

a wide variety, sometimes very technical, also giving guidance for implementation

codes and guidelines are easier to amend

in practice these instruments are implemented as if they were legal binding conventions, the difference is that there are no sanctions



SHEET 3

these codes address a very sepcific issue requiring specific measurers

for example for dangerous goods, timber, grain, bulk cargoes

they spell out in detail the carriage requirements on board a ship and also contain requirements for packing and stowage

most of the codes are developed for safety under the SOLAS Convention but in some of these codes environmental issues are also incorporated nowadays

ANNEX IV

- Regulation 8 validity of Certificate
- Regulation 9 sewage systems
- Regulation 10 standard connections
- Regulation 11 discharge of sewage
- Regulation 12 reception facilities

SHEET 4

imo provides support for the implementation of the conventions

regional advisers

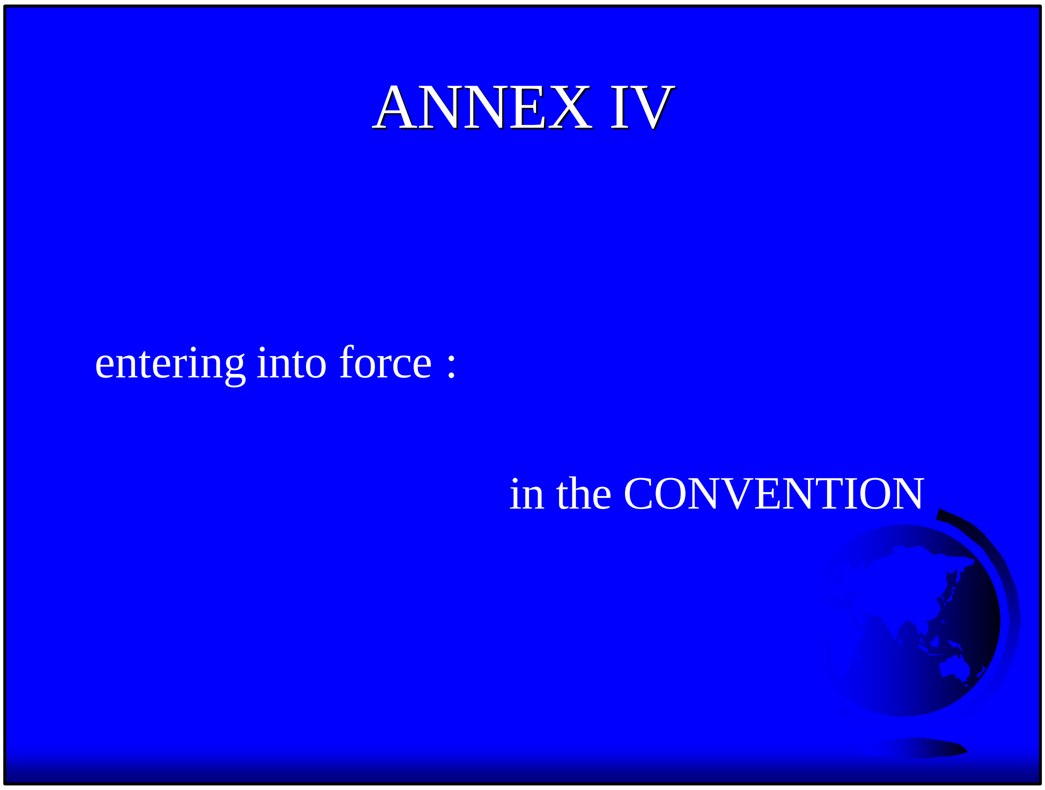
organising seminars, courses, conferences in close co-operation with UNEP and UNDP

funds raised from donor countries

WMU in Malmo

academy in Trieste for short courses

Maritime Law Instutute in Malta



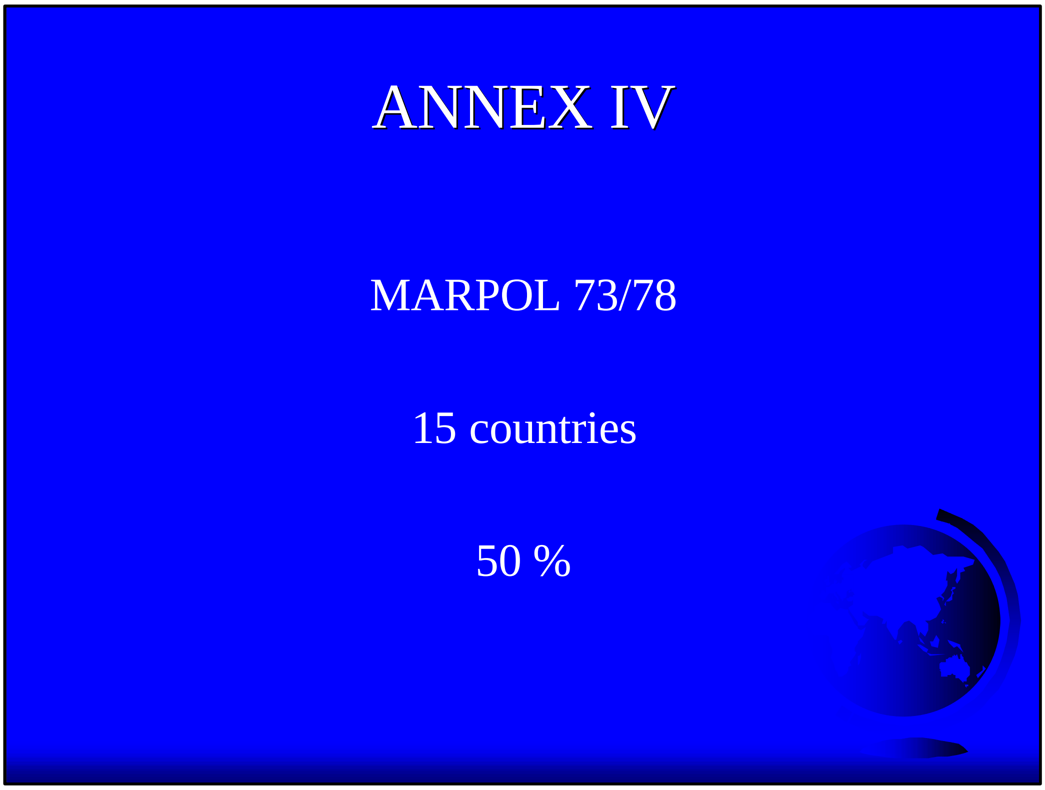
SHEET 5

each convention its own rules

always related to the number flagstates and worldtonnage

conventions only enters into force if sufficient Parties to it

ratification of a convention is not enouigh, it is more an indication of intention of a government to become a praty to that convention soon



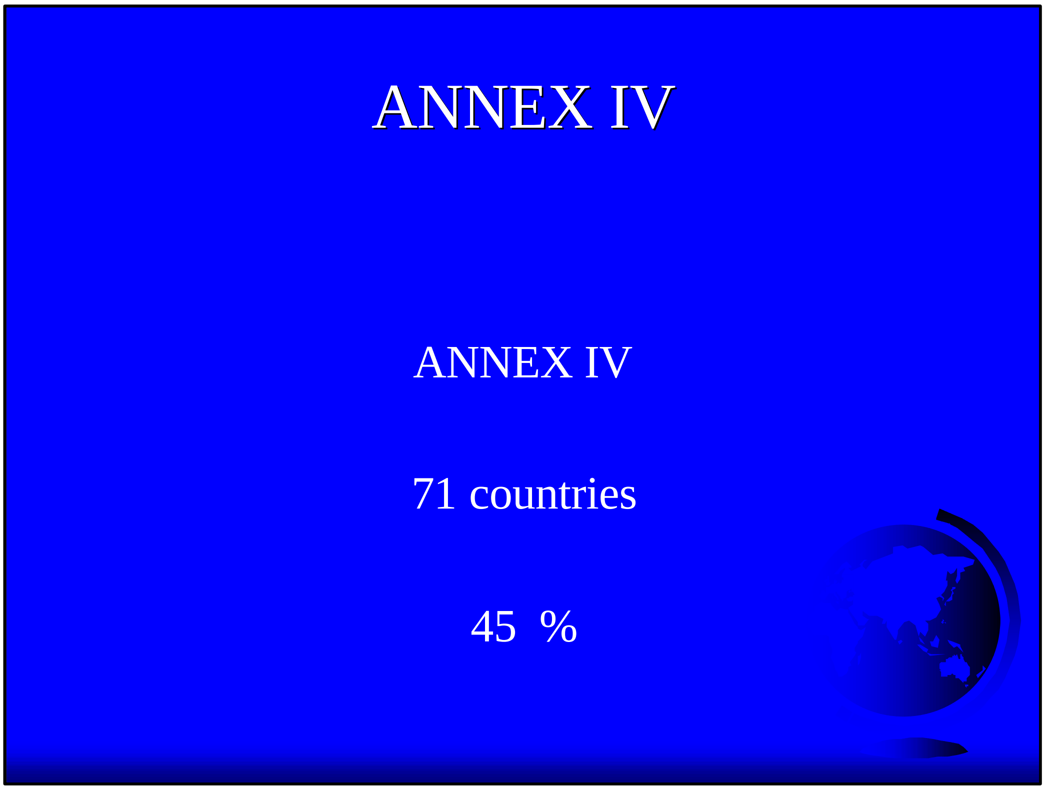
SHEET 6

MARPOL now 104 countries and 93,8 %

Annex III = 87 countries and 79,1 %

Annex V = 89 countries and 82,6 %

Annex VI = 1 country and 0,53 %



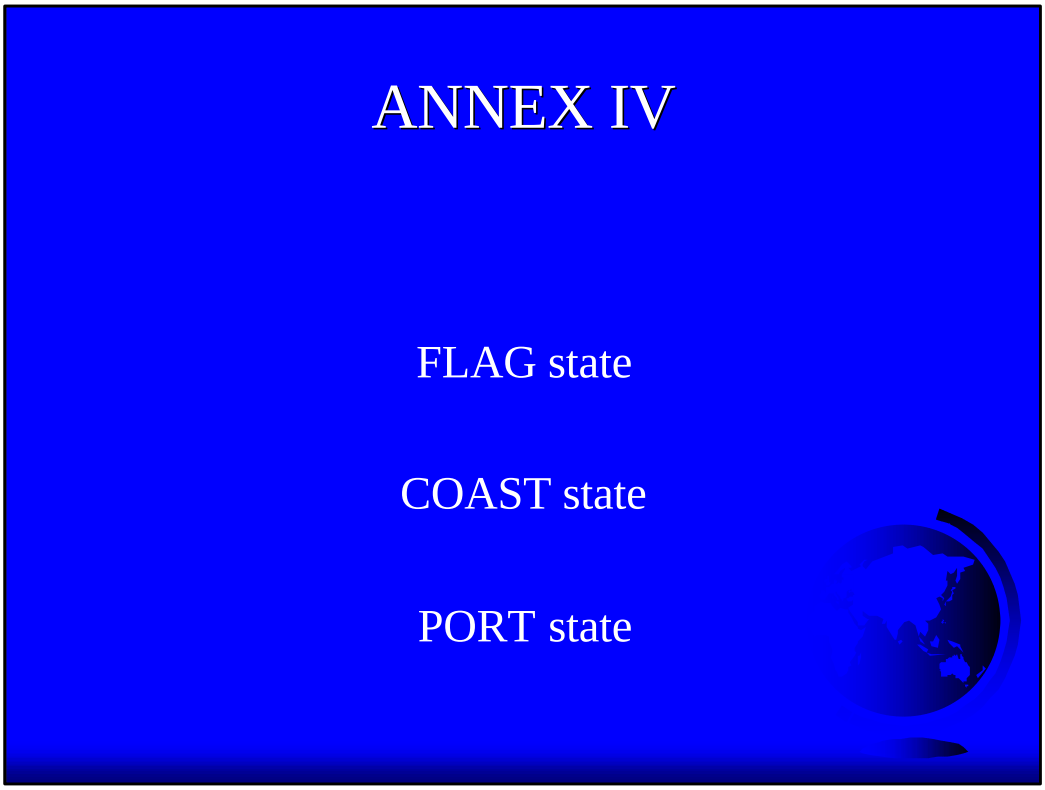
SHEET 7

these numbers are increasing very slowly, indicating that annex iv has a low priority

it may also be questioned whether or not the right criteria are used

more than 70 countries is not enough, there are probably many countries with a small fleet

are there other ways ?



SHEET 8

Flagstate and tonnage criterion in use for many years

a good reason for that

especially for safety conventions since there is a direct interest of the Flag State

environmental conventions is more the interest of coast and port states

therefore, their interests should also be taken into account, more than now

SHEET 9

ensure ***compliance*** of the flag states with the technical requirements

issue ***certificates*** for those ships

carry out ***inspections***, not only for the own ships but also as port state

violations shall be prohibited by national law

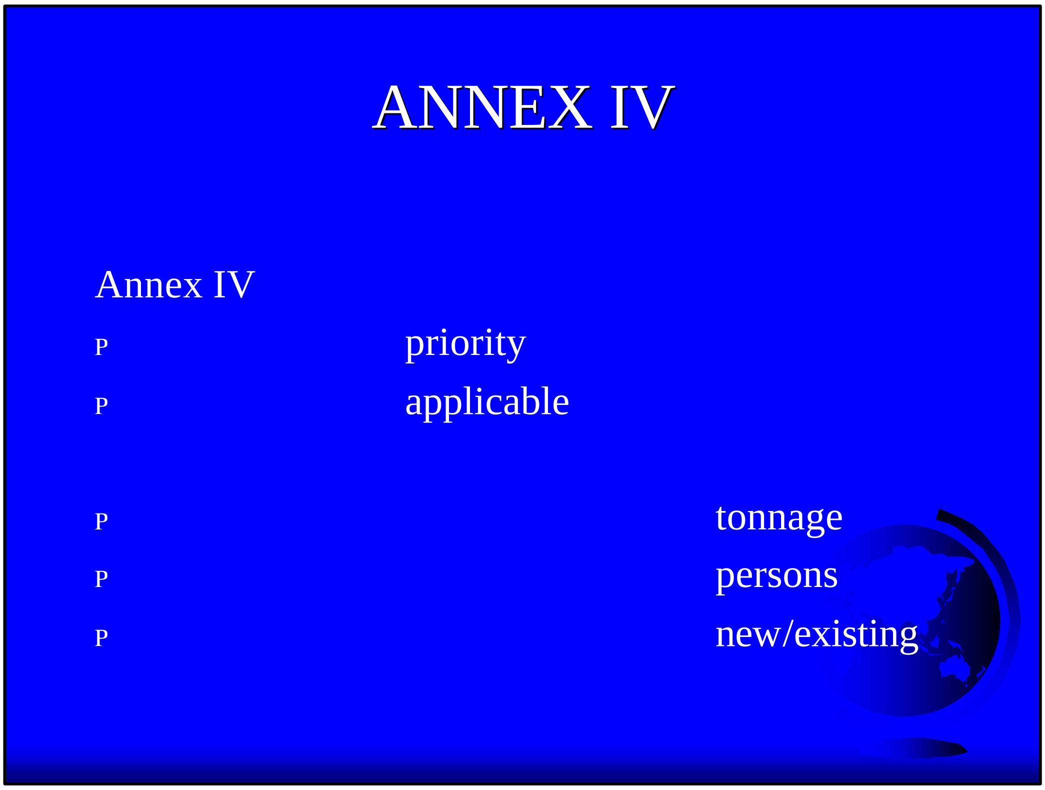
evidence to be collected, if necessary with other states

sanctions shall be established against violators

example of sanction against a cruise liner throwing over the side some 10 plasic bags of Annex V, fine $ 500.000.-

communication to the Organisation of laws, certificates, agencies acting on behalf of, list of reception facilities, etc. etc.

investigate casualties with a deleterious effect upon the marine environment



SHEET 10

low priority because the environmental impact of annex IV is very low

was:

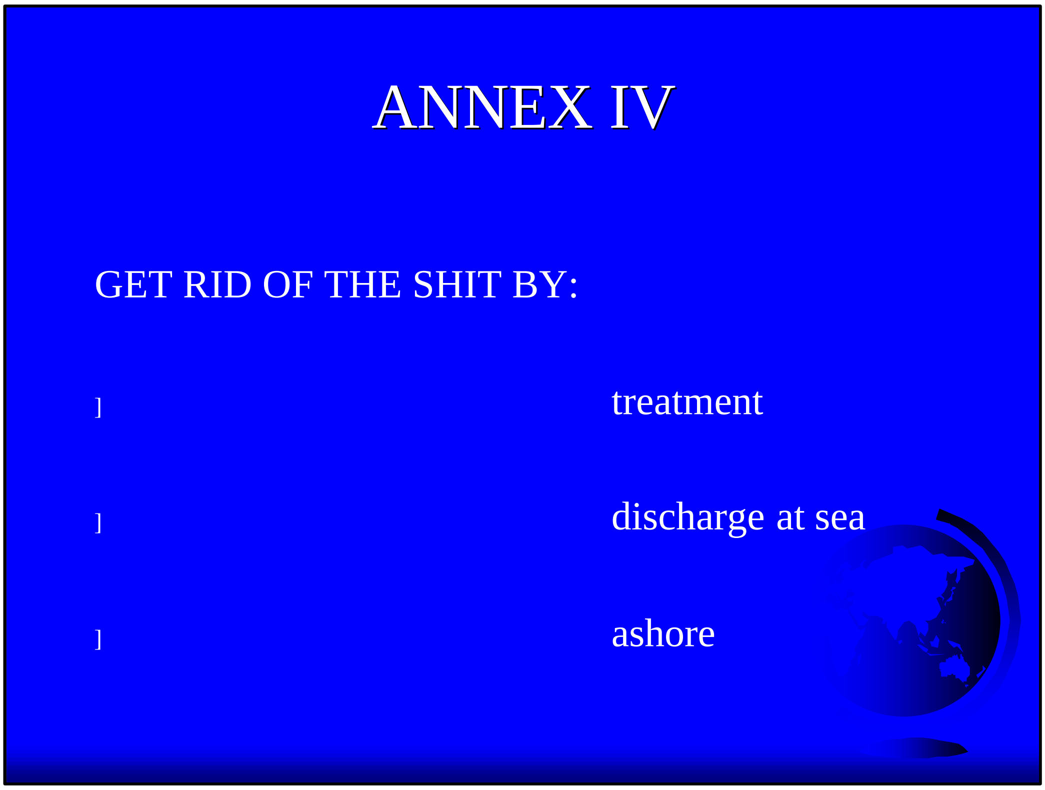
applicable ships of 200 tons or more, carry more than 10 persons

new or existing (10 years after the entry into force of the annex)

now:

400 tons and 15 persons

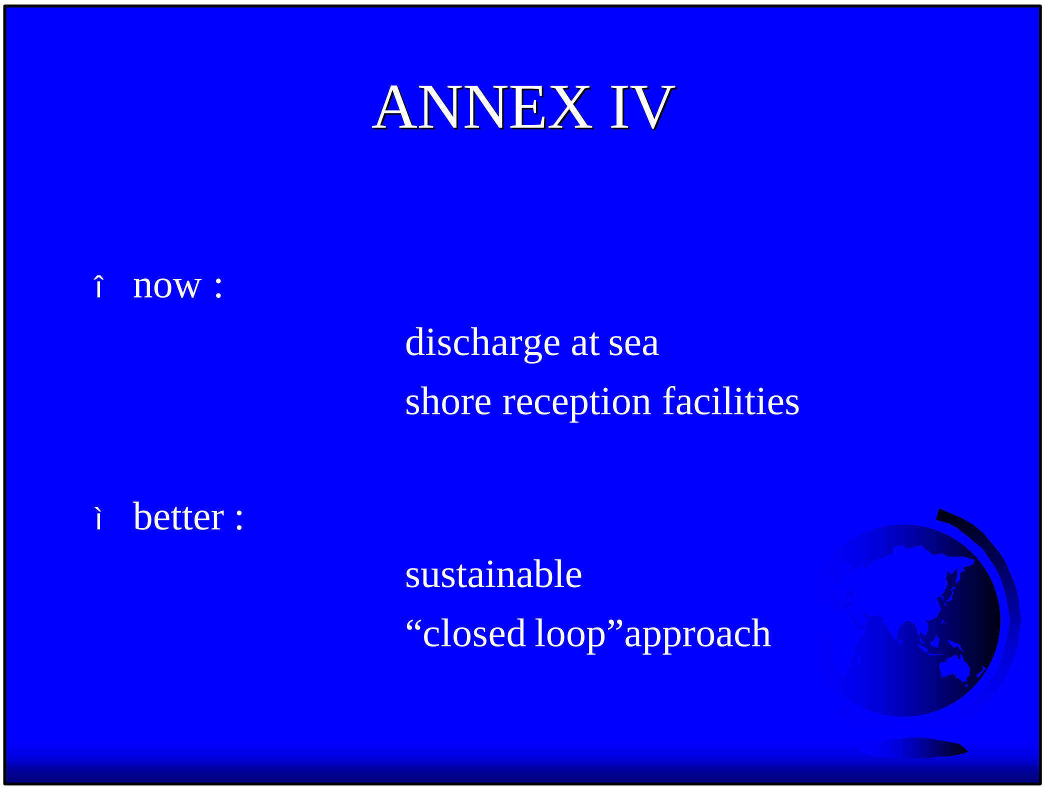
new and existing (5 years after entry into force of the annex)



SHEET 11

requirements of annex IV:

equipment for treatment required
treatment of sewege on board
discharge into the sea under conditions
disposal of to a shore recpetion facility



SHEET 12

the MARPOL Convention ir regulating the discharges at sea settin criteria for such discharges

in addition shore reception facilities shall be provided while the ship may discharge at sea, that is not in balance

we should aim at a more sustainable solution, which benefits all incvluding the shipping sector

a closed loop approach would solve many of todays problems including the provision of reception facilities

ANNEX IV

– Sewage = grey and black water

– New 5 (10) years

– Existing

ANNEX IV

- APPLICABLE:
- > 400 (200) GT
- < 400 (200) GT   > 15 (10) persons

ANNEX IV

- CERTIFICATE
- H.S.S.C.
- Harmonised with other Annexes
- other Conventions

ANNEX IV

- EQUIPMENT:

- Treatment plant or
- Disinfection system or
- Holding tank

ANNEX IV

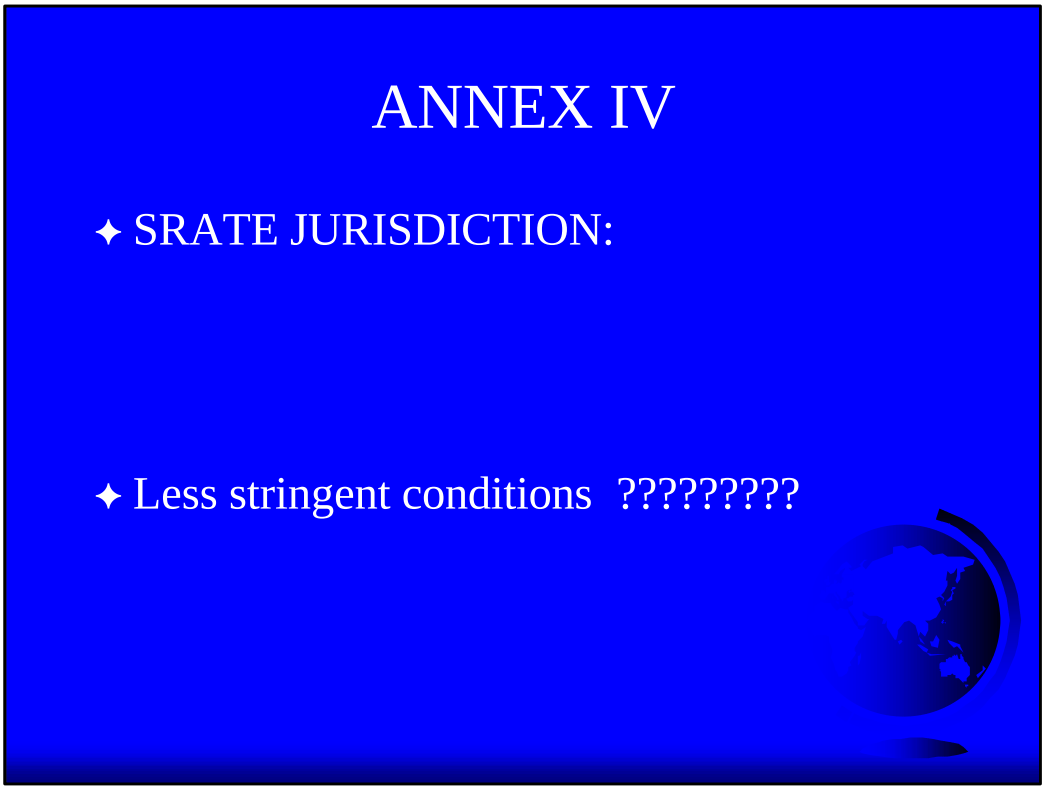
– DISCHARGE:

– 3 miles = disinfected

– 12 miles = other sewage

– en route and 4 knots

– OR treatment plant


ANNEX IV
✦ SRATE JURISDICTION:
✦ Less stringent conditions ?????????

ANNEX IV

- EU DIRECTIVE 2000/59

- Reporting
- Mandatory disposal
- Financing
- Control/enforcement
- Monitoring

ANNEX IV

- ✦ PROTOCOL of MADRID
- ✦ Applicable > 10 persons
- ✦ Discharge 12 ‘ land/ice shelves
- ✦ Monitoring sew. record book

CURRICULUM VITAE

HOLGER HAMANN

BORN: 10.01.1961
HAMBURG / FED. REP. OF GERMANY
MANAGING DIRECTOR OF TECHNICAL DEPARTMENT WITH HAMANN WASSERTECHNIK GMBH
MANUFACTURERS OF WASTE-WATER-TREATMENT-SYSTEMS

RESPONSIBILITIES:

WORKS FOR CERTIFICATIONS

NOV. 1984	CONDUCTION OF 10 DAYS TEST WITH USSR- REGISTER COMPLETE SERIES TYPE-TEST 1-15 CBM/HR
DEC.1984	CONDUCTION OF 10 DAYS TEST WITH RINA FOR MINI-PLANTS
MARCH 1985	CONDUCTION OF 10 DAYS TEST WITH RINA FOR 4 CBM/HR PLANTS RENEWAL-TESTS AND CERTIFICATION FOR VARIOUS CERTIFICATES.

COMPUTERISATION

1984	START OF DATA-SYSTEM
1996	WATCHING AND MODERNISATION AND CHANGE TO NEW SYSTEM

WORKING AS FIELD ENGINEER

SINCE 1985	START-UP AND TROUBLE SHOOTING ON NAVY- VESSELS, PASSENGER- SHIPS AND DRILLING-RIGGS KNOWLEDGE OF PHYSICAL WORK ON BOARD
TO-DAY	ONLY AVAILABLE FOR ABOVE MENTIONED JOBS IF THEY ARE ATTRACTIVE AS FOR NORMAL JOBS THERE ARE SEVERAL SERVICE STATIONS AROUND THE WORLD.

DESIGN

SINCE 1986 RESPONSIBLE FOR THE TECHNICAI SIDE OF NEW DESIGNS.

QUALITY ASSURANCE

SINCE 1993 TAKING OVER THE RESPONSIBILITY FOR THE TECHNICAL SIDE INCL. THE F.A.T.

SALES

SINCIE 1995 TAKING OVER SALES IN THE NETHERLANDS AND THE USA

SUMRISE

AN ALLROUNDER WITH STRONG POINTS IN TUE TECHNIQUE

Abstract

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"BLACK WATER PRE-TREATMENT AND REAL SITUATION ON BOARD"

1. PART
IMO/USCG CERTIFICATION, INLET – AND OUTLET WATERS

2. PART
REAL SITUATION ON BOARD, WITH PICTURES OF RAW SEWAGE EXPLAINING THE MATERIAL IN THE RAW SEWAGE AND THE DIFFICULTY OF TREATMENT.

3. PART
HAMANN's SaP – SCREEN and PRESS SYSTEM.
SCREENING THE SEWAGE DOWN TO 1000 µm.
EXPLAINING FUNCTION AND THE ADVANTAGE OF INSTALLING THIS SYSTEM PRIOR TO ANY KIND OF WASTE-WATER TREATMENT-PLANTS AND THE EASY HANDLING OF THE DRY SCREENED SOLIDS

4. PART
THE NEXT STEP OF BLACK-WATER PRE-TREATMENT CAN BE THE "PI-100 SERIES" FOR THE FINE FILTRATION OF RAW SEWAGE DOWN TO 60 – 20 µm.
EXPLAINING FUNCTION AND THE SELF-CLEANING MECHANISM.

Hamann Wassertechnik GmbH

BREMERHAVEN

BALLAST WATER, WASTE WATER, AND SEWAGE TREATMENT ON SHIPS AND IN PORTS

BY HOLGER HAMANN

IMO/USCG CERTIFICATION, INLET – AND OUTLET WATERS

First of all I want to point out that still a rumour is going around the world about the possible alteration of IMO-regulations for waste-water-treatment-plants to something more stringent Regulations and that in the future only SPECIALIZED-UNITS will be allowed to treat black-water.

In this respect, please, take into consideration the following wording in a letter dated 2.12.99 from the SBG (See-Berufsgenossenschaft). The SBG is the German authority that provides accreditation for IMO–certification:
.... any treatment plant with its own "treatment philosophy" and which operates in accordance to the IMO/Marpol regulations will be allowed to treat black-water in restricted areas.

The existing regulations will not be altered for the time being.
Since 1976 (25 years have passed in the meantime) no international agreement could be signed for world-wide compelling rules. This, of course, is due to the act that many ships are running under foreign flags of poor and/or tax-free countries.

CONCLUSION

Due to the fact that IMO/MARPOL are not going to alter the regulations some areas have started to make their own rules – the so called **"zero discharge-zones".** Look at Florida with its important cruise-harbours Miami and Fort-Lauderdale – the KEY`S and in Alaska , where passenger-vessels are cruising or lying and waiting. These areas are "zero discharge zones" where the ships are not allowed to discharge any treated water.
WHY ?

There are certain treatment-plants on the market which don`t fulfil the requirements under routine ships conditions.

In addition, there are ships crews and engineers who are against working with sewage. Specially if the systems getting too complicate.

Specially if the systems are getting too complicate.

No wonder some Governments have closed their territorial waters in order to protect their coast lines and the whole environment.

BACK TO THE REGULATIONS

The IMO-rules define sewage water as described in the following manner:
“ for the certification test the inlet-water shall show a minimum of 500 mg/l of suspended solids”

More stringent definition comes from the USCG as they declare that:
“the inlet water must also show coliform bacteria”.

Outlet water shall show

on board:			ashore:		
Suspended solids	less	100 mg/l	Suspended solids	less	50 mg/l
BOD5	less	50 mg/l	BOD5	less	50 mg/l
Coliform bacteria	less	250/100ml	Coliform bacteria	less	250/100ml

NEARLY ALL SEWAGE TREATMENT PLANTS ARE TESTED ASHORE !

IN REAL THE SEWAGE TREATMENT UNITS HAVE TO FIGHT AGAINST:

Inlet water: **2500 - 3000 mg/l BOD5**

How to reduce the BOD
Removing as much of the solids as possible will also help with the BOD by reducing the amount of organic solid material in the water, but it will not remove the 2nd source of BOD, the dissolved nutrients. On modern vessels with vacuum black water systems, the BOD of the highly concentrated sewage can be as high as 2500 mg/l to 3000 mg/l. It is common knowledge, that a biological sewage treatment will remove up to 96% or 98% of the BOD, ……if everything is working perfectly. However, the metabolic activity of the micro-organisms present in the activated sludge will result in new BOD, which will show up in the effluent.

One can assume, that the total BOD at the end of the biological treatment will be anything between 2% to 7% of the original value. These results can only be achieved, if the aeration period is long enough (e.g. 6 to 8 hours) and a sufficient amount of activated sludge is available for the process. The final BOD of the concentrated sewage on board of modern vessels after a biological treatment could be between 50mg/l and 210 mg/l. Question is here how to bring the level down to 50 or even 30mg/l.

IN REAL THE SEWAGE TREATMENT UNITS HAVE TO FIGHT AGAINST:

Inlet water: **2500 - 3000 mg/l Suspended Solids**

Some of the sources for the high TSS are:Fibres, Hair, Plastic, Seeds, Rubber and Metal like Razorblades

How to reduce the TSS?Any particles can be removed by physical separation (e.g. filtration). The efficiency of the filtration is depending on the size and shape of the particles as well as on their numbers. As a role of thumb one can say: The finer the filtration, which means the pore size, the less volume of water can be treated with the same filter surface during a specific time interval.

As for black water, the TSS may be as high as 3000 mg/l on modern vessels with vacuum systems. The particles causing the biggest problems are fibres from toilet paper and hairs, because they tend to block the filters when they are stuck in the pores. The 2nd problem is the bio-fouling on the filters. This bio-fouling occurs, when bacteria start to grow on the filters. Normally they can not be removed in the standard back-wash procedure and chemicals have to be used to keep the filters clean.

BLACK-WATER PRE-TREATMENT

1998 HAMANN WASSERTECHNIK developed together with the Company KLEIN the so called **SaP** (Screen and Press).

This unit is designed as a pre-step before entering any kind of sewage treatment system.

We have now around 30 Sap`s running successfully on Cruise Vessels and are in the 6th generation screening now black-water down to 1mm.

Hamann Wassertechnik GmbH

SaP FUNCTION

The system works very simple:
From a black water holding-tank the sewage is normally transferred to the sewage treatment unit.
The **SaP** will be installed in between this line.
The SaP screens out all untreatable particles like plastic, paper, rubber and metal down to 1mm.
The screened particles will than be pressed into a dry cake.
The dry cake falls into a plastic sack.
The solids can than be easily burned in the incinerator = no problem with sludge !

ON THE END ONE LAST INFORMATION

Hamann Wassertechnik worked in co-operation with the USCG the last three years to build up certified laboratories in Germany in order that German manufacturers can make their USCG type II certification at home.

In 2000 the USCG certified an "Independent Laboratory" for the biological test.

In 2001 the USCG certified a "Recognised Independent Laboratory" for the mechanical test.

In order to get the relevant addresses please feel free to contact
Hamann Wassertechnik.

CURRICULUM VITAE

Personal Data:

Name:	**Steffen Richter**
Degree:	Qualified Engineer (Diplom-Ingenieur (FH))
Date of birth:	May 27, 1971
Place of birth:	Balingen
Marital status:	Married with one son

Education /Qualifications:

1991	School-leaving exam plus university entrance qualification (“Abitur”)
1991 – 1992	Alternative service
1992 – 1994	Chemistry course at the University of Paderborn
1994 - 1999	Course in Technical Environmental Protection at the University of Paderborn, Branch Höxter
October 1999	Degree (Qualified Engineer, FH) in Technical Environmental Protection, primary subject: waste water; diploma thesis: Industrial Waste Water Treatment by the Membrane Process

Additional Qualifications, Sideline Activities and Employment:

1992 – 1998	Sideline occupation as salesperson
March 1 - September 23, 1994	Practical training in the Office for Public Facilities and the Office for Town Waste Water Disposal of the City of Paderborn
March 17 - August 15, 1997	Practical semester at enviplan Ingenieurgesellschaft mbH, Lichtenau; primary subject: solids separation by flotation
February15 – December 31, 1998	Employed by enviplan Ingenieurgesellschaft mbH, Lichtenau, as Project Manager for a project in Canada
since January 1999	Project Engineer and Project Manager at VA TECH WABAG Deutschland GmbH & Co. KG, Ratingen; primary subject: membrane technology and maritime waste water treatment

Abstract

Steffen Richter, VA-TECH WABAG, GE
Manuel Finner, Dr. Wessling Beratende Ingenieure, GE
Olaf Petersen, GAUSS, GE

"MEMROD Project"

The discharge of wastewater from seagoing vessels is governed by national and international law. Although the international regulations are not yet ratified, public pressure on shipping companies is mounting due to the call for environmentally compatible navigation, which will result in a need for efficient and space-saving wastewater treatment systems. The technology currently installed on ships has a number of shortcomings. Transfer of land-based systems to ships has often ignored the specific conditions ruling at sea. Particular problems in regard to the process technology are encountered in the sedimentative final clarification process and - in regard to the environment - in the subsequent chlorine treatment that serves for disinfection. The MEMROD® reactor (**MEM**brane **R**eactor **O**peration **D**evice) applies to ships the process of biological wastewater treatment in combination with submerged low-pressure micro-filtration membranes, which act as barriers to the activated sludge as well as to bacteria and viruses. So the technology produces - without any final clarification - water that meets the quality standards for bathing waster.

A research project sponsored by the German Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMB+F) is under way to study the use of the MEMROD® technology for cleaning all wastewaters produced on ships and to optimise the process technology. Black and grey wastewaters as well as pre-treated bilge water are cleaned in the bioreactor. This project is jointly carried out by the cooperation partners VA TECH WABAG, Dr. Weßling Beratende Ingenieure (WBI), and GAUSS, Gesellschaft für angewandten Umweltschutz und Sicherheit im Seeverkehr. As part of this research project, three ships will be equipped with reactor systems and monitored over a one-year period.

The MEMROD® Project

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Abstract

The discharge of wastewater from seagoing vessels is governed by national and international law. Although the international regulations are not yet ratified, public pressure on shipping companies is mounting due to the call for environmentally compatible navigation, which will result in a need for efficient and space-saving wastewater treatment systems. The technology currently installed on ships has a number of shortcomings. Transfer of land-based systems to ships has often ignored the specific conditions ruling at sea. Particular problems in regard to the process technology are encountered in the sedimentative final purification process and - in regard to the environment - in the subsequent chlorine treatment that serves for disinfection. The MEMROD® reactor (**MEM**brane **R**eactor **O**peration **D**evice) applies to ships the process of biological wastewater treatment in combination with submerged low-pressure micro-filtration membranes, which act as barriers to the activated sludge as well as to bacteria and viruses. So the technology produces - without any final purification - water that meets the quality standards for bathing water.

A research project supported by the German Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMB+F) is under way to study the use of the MEMROD® technology for cleaning all wastewaters produced on ships and to optimise the process technology. Black and grey wastewaters as well as pre-treated bilge water are cleaned in the bioreactor. This project is jointly carried out by the cooperation partners VA TECH WABAG, Dr. Weßling Beratende Ingenieure (WBI), and GAUSS, Gesellschaft für angewandten Umweltschutz und Sicherheit im Seeverkehr. As part of this research project, three ships will be equipped with reactor systems and monitored over a one-year period.

Current Status of Wastewater Treatment on Ships

The discharge of ship wastewater is regulated in Annex IV of the international IMO regulations (MARPOL 73/78). That annex generally prohibits the discharge of defined wastewaters, except where such wastewaters have been treated and disinfected in an officially approved treatment facility. In current facilities, black water is mainly treated biologically, while grey water is only disinfected with a chlorine bleaching agent in the secondary treatment stage – along with the biologically treated black water.

Although the requirements of MARPOL 73/78, Annex IV, are not very extensive (see Table 1), compared to the regulations for onshore treatment facilities, the provisions of the annex have not been ratified as yet. The nations that have to date signed this international convention account for only 41.5% of the world trade tonnage instead of the required 50%.

Table 1 Requirements for the Discharge of Treated Black Water

Faecal coliforms	max.	250 (250)	CFU/100 mL
Suspended solids	max.	50 (100)	mg/L
Biochemical Oxygen Demand (BOD_5)	max.	50 (100)	mg/L

The figures in brackets relate to operation in heavy seas.

Although Annex IV is not yet ratified, the maximum values are indicative of the future trend. The international agreements have been translated into national regulations, some of which go so far as to define zero-emission areas where any discharge of wastewater is prohibited. One reason for such strict regulations is that the cleaning efficiency of the wastewater treatment facilities currently installed on ships is often insufficient.

The poor cleaning results of the current ship wastewater systems are due, among other things, to the fact that the standard secondary treatment stage of onshore systems – sedimentation – was simply transferred to offshore treatment systems. Studies have shown that large volumes of biomass escape from the systems in heavy seas. Due to a lack of biomass, the removal of water contaminants is significantly reduced in the biological stage. It is known from experience that, as a result of operating trouble, conventional systems are frequently shut down, throughly rinsed and started up again, so that optimum operating conditions cannot be achieved.

The MEMROD® Principle

The MEMROD® reactor (**MEM**brane **R**eactor **O**peration **D**evice) was developed based on the biological wastewater treatment technology in combination with submerged micro-filtration units and optimised for use on ships. The micro-filtration units are directly installed in the bioreactor. The biologically cleaned wastewater is withdrawn exclusively through the membranes which form a barrier to the activated sludge, suspended solids, bacteria and even viruses.

The oxygen required for the aerobic degradation of the water contaminants is introduced through the aeration units arranged below the membranes (see Fig. 1). Due to the upward flow within the membrane module, the membrane´s surface is permanently swept and freed of adhering solids. The low suction pressure of 0.1...0.2 bar (max. 0.6 bar) on the transmembrane side effectively prevents solid filter cakes from building up on the membranes.

Fig. 1 Membranerack

Low-pressure membranes are already being used for many applications in onshore systems and their range of uses is constantly increasing. In regard to wastewater treatment on ships, the system offers the following advantages:

- Compact process due to high sludge dry substance in the reactor. This enables the scarce space on ships to be made available for other useful purposes.
- Simple, largely automated process, which is convenient to operate for the crew, thus minimising comprehension and acceptance problems.
- Removal rates are significantly better than what is required by current legislation. This gives operators the confidence that they will meet all likely future legislation and may even be allowed to discharge wastewater in areas where this is currently prohibited (zero-emission areas).
- Possibility to treat all wastewaters (black, grey and bilge waters) in <u>one</u> reactor. This provides potential to save further expensive and space-intensive equipment. Operators may for instance continue using a standard gravity oil-water separator instead of a (vulnerable and expensive) membrane oil-water separator. Residual hydrocarbons in the bilge water are reduced in the membrane treatment plant by micro-organisms.
- There is no need for an environmentally harmful and expensive secondary treatment stage for disinfection. Secondary chlorination, which is indispensable in conventional systems, is not necessary for biological membrane systems. The technology produces - without any final treatment – water that meets the quality specifications of the EU Bathing Water Directive. The use of the treated wastewater as service water, for instance for nitrogen removal from exhaust fumes, is conceivable and possible.

The BMB+F Research Project

Based on a study conducted by the „Bundesamt für Wehrtechnik und Beschaffung (BWB; (German Federal Office for Military Technology and Procurement)), a prototype membrane reactor was developed and built by VA TECH WABAG in 1997 and extensively tested by Dr. Weßling Beratende Ingenieure (WBI) until 1999. After completion of the onshore tests, the reactor was tested under offshore conditions on the German Navy (class 701) submarine tender “MEERSBURG”. The reactor operated without a hitch and to the full satisfaction of the crew[1].

In response to the successful BWB study, a research project (MEMROD) to treat typical ship wastewater in a bio-membrane reactor was launched in September 1999 by Dr. Weßling Beratende Ingenieure (WBI), Gesellschaft für Angewandten Umweltschutz und Sicherheit im Seeverkehr (GAUSS) and VA TECH WABAG. The project is supported by the ”Bundesministerium für Bildung und Forschung“ (BMB+F, Federal Ministry for Education and Research) (Promotion File No. 02WA9964/5).

The special thing about the research project is the combined treatment of all wastewaters produced on ships. Thus the waters treated include not only black and grey water, but also conventionally pre-cleaned bilge water. The biological treatment of all wastewaters in the MEMROD® reactor is intended to confirm the economic and ecological advantages of this process compared to the wastewater treatment systems currently in use. As part of the BMB+F research project, three ships will be equipped with this technology. The objective of the project is to prove the functionality of the combined wastewater treatment and its applicability to actual operation at sea as well as to develop a commercial product.

The following ships will be equipped with MEMROD® reactors:

- Deep sea tug “OCEANIC“, Bugsier-, Reederei- und Bergungs-AG, Hamburg; the ship is chartered by the Federal Republic of Germany. Based in the German Bight, the vessel serves as an ETV (to prevent adverse effects from damaged ships). The pilot unit is designed for 25 people. The “OCEANIC” operates primarily in heavy seas, so that the treatment system can be tested under such conditions.
- 1150 TEU container vessel “SAFMARINE IBERIA“, Kapitän Manfred Draxl Schiffahrts GmbH & Co. KG, Haren/Ems.
  Her aera of voyages is primarily in southern waters, which makes it possible to test the effect of warm ambient temperatures on the biological treatment system. The ship has about 17 people on board.
- RoPax ferry “TRANSEUROPA“, Finncarriers Deutschland Schiffahrt AG, Lübeck. The ferry plies between Lübeck und Helsinki (Finland). This ship was chosen to test the influence of peak loads on the biological treatment unit. Currently the maximum capacity of passengers is 125 people. After a planned renovation the number of passengers will increase up to 230 persons.

In parallel to these offshore pilot units, an onshore system is tested by WBI at the municipal sewage treatment plant Altenberge. This operational test was preceded by successful laboratory tests.

A work group has been set up to support the project. Any interested party may obtain information on the status of the tests in workshops or online through the GAUSS Information Center (http://www.master-info.org).The members of the project-supporting work group have access to more specific information on that website. The members of the project supporting group are decision-makers from shipyards, shipping associations and classification societies as well as other relevant organisations and shipping companies.

[1] Under the name of “MEMROD LT 10”, the reactor was approved for operation at sea by the classification society (Maritime Employers’ Liability Insurance Association).

The Information exchange

To achieve early information of the shipping community and early acceptance for MEMROD, the GAUSS institute set up an information exchange system and knowledge database in the www.
It is called

http://www.MASTER-INFO.org

(Maritime Safety-, Technology- and Environmental Research INFOrmation server)

MASTER-INFO.org is used for project work because professional an effective Research and Development needs fast information exchange, especially if partners are working in different cities or countries. It is essential to get easy and fast access to relevant information.

While resources and finances are shortened all over the world, highest effort should be given to avoid "double work" on one topic. Nobody can efford this anymore and so everybody needs to be informed. Contribution to the improvement of "sustainable development" is another reason to spread available information as wide as possible. Especially in our field of work: Solutions for sound environmental protection. Last, but not least information exchange is the best way to develop new ideas and to find partners for the realisation of these ideas. So let us get in touch.

The www is always accessible, cost efficient, and its use is not depending on a location.

That is why we initiated a so called "Virtual Information Centre" (VIC) on the www-base.
The software used is HYPERWAVE, a software that describes best as an information-platform and knowledge-management-system.

- Many people are involved in the MEMROD-project and working together.
- Most of the partners are working in different cities, spread over Germany.
- To work together in an effective way we needed a virtual file cabinet.

The developed MASTER-INFO allows for the partners an access to and an exchange of all necessary internal project data and allows an access for the public to defined project information.
MASTER-INFO can be used as a forum where new ideas, aspects, and solutions can be discussed on different access levels.

The software used is designed to create a site that consists of different parts: A "Public Area" and a "Non Public Area":

- By means of a password partners will get access to all relevant documents like working-papers, comments, reports, measuring results, schedules, and so on.
- Without a password you will have access to general information on the project, published reports and several other items.

For a user name and password you have to subscribe at the information system.
It is free of costs!
Most information are laid down as .PDF - Files.
You will need the software **Acrobat Reader**® (by Adobe) to read the files.
Download is possible from: http://www.adobe.com/products/acrobat/readstep.html

Using MASTER-INFO will increase speed and efficiency of information flow and by this consequently increase also the efficiency of work in general.
The information system is an easy and practicable solution to give information to a wide range of interested people as well as to the project partners.

The MASTER-INFO server is also available via links from the home pages of the project partners:

- www.gauss.org
- www.vatechwabag.com
- www.wessling-gruppe.de

How to use MASTER-Info

On the following sheet you will get a short introduction how to log on and use MASTER-Info.
More **details** you will get at MASTER-Info in the right part of the screen at **Register „allg. info"** in the **user manual for MASTER-Info"** (open by click on the left mousekey-, then open the **attachment „Manual"**).
If you visit MASTER-Info the first time you will get the following view:

Sheet 1: Discription of MASTER-Info by screen shots

Results of Laboratory Tests

For the laboratory tests that served for initial orientation, a laboratory-scale reactor with a capacity of 0.1 m³ and equipped with small-size membrane plates was developed and built. To simulate realistic conditions, pre-cleaned bilge water was obtained from various ships for treatment in the reactor. The sanitary water share was simulated using municipal wastewater mixed with dairy wastewater.

The process stability of the laboratory reactor was controlled by measuring the following parameters in the influent and effluent as well as in the reactor: COD, BOD_5, mineral-oil-type hydrocarbons, lipophil substances, suspended solids, coliforms and dry substance.

The average test parameters were as follows:

Table 2 Parameters in laboratory reactor

Transmembrane pressure differential	-0.05	bar
Effluent (Q_{ab})	7.5	l/h
Flux	13.3	l/(m² · h)
Influent, municipal wastewater ($Q_{zu, kommunal}$)	4.8	l/h
Influent, bilge water ($Q_{zu, Bilge}$)	0.8	l/h
Influent diary ($Q_{zu, Diary}$)	1.9	l/h
Temperature	18.5	° C
pH value	8.0	
O_2 content	4.2	mg/l

In the first test phase, the laboratory reactor was fed with bilge water from a container vessel (fuel: HFO, hydrocarbon concentration: approx. 0.7 mg/l) and in the second test phase with bilge water from a tugboat (fuel: MDO, hydrocarbon concentration: approx. 170 mg/l).

In neither of the two cases was the bilge water found to have a toxic or impeding effect.

During the second test phase, a mixture of old deep-frying fat, kitchen cleaner as well as oils and cooling lubricants were added to the influent (starting on 7 April 2000). The intention was to simulate worst-case conditions on a ship and to acquire data on how fast the treatment system regenerates after overload operation. It can be seen from the COD figures that the COD in the effluent rises only slightly to 147 mg/l and then drops quickly again to its previous low level. Only under deliberately simulated extreme overload conditions does the COD rise significantly also in the effluent, but it recovers quickly as soon as the load is back to normal. The control parameter BOD_5 stayed below the detection limit of 3 mg/l during the entire measuring period and the mineral-oil-type hydrocarbons usually remain below their detection limit of 0.1 mg/l as well.

Diagram 1 COD Influent and Effluent Values

Diagram 2 BOD_5 Influent and Effluent Values

Diagram 3 Mineral-oil-type Hydrocarbons in the Influent and Effluent

Trial Reactor „OCEANIC“

Based on the results obtained from initial informative tests a design and construction concept has been elaborated for the MEMROD® reactor and the respective equipment installed on board of the ETV OCEANIC. The trial plant was installed during normal ship operation at sea to avoid “off hire” time and to assure that the shipping safety in the german bight can be supported by the ETV OCEANIC at any time. Since the MEMROD equipment is operated for testing purposes the existing conventional wastewater treatment equipment had to be left on board and was made part of the process as a mixing and equalization tank. Due to its compact size and a construction concept tailored to the application the new treatment unit could be taken aboard without problems during the scheduled bunkering stop at Cuxhaven without interfering unduly with the respective bunkering activities and without having to shut down operative ship components. After the mounting and commissioning period of one week at sea the plant is in operation since March 2001, without significant trouble. A view to the results of the sewage samples taken from the raw sewage and the effluent (permeate) is given in the following table.

Table 3 Results of sewage samples since May 2001, average concentrations

Parameter		Raw sewage	Effluent
COD	[mg/l]	800	50
BOD_5	[mg/l]	350	< 5
Fat	[mg/l]	80	< 10
Coliform germs	[1/ml]	> 1 x 10^6	< 10
Suspended solids	[mg/l]	> 750	< 10

As the results show, a clarification of the raw sewage strictly below the recommendations of the IMO is provided without any chlorine treatment or further disinfection. The quality of the effluent meets the standard of bathing water in the European Union.

Trial on board SAFMARINE IBERIA

The second ship chosen to be equipped with a MEMROD® reactor is the 1,150 TEU container vessel SAFMARINE IBERIA. Her scheduled route takes SAF IBERIA along the african west coast from Capetown to Algeciras in south Spain. The following route leads her over Vigo back to Algeciras and further back to Capetown. To avoid "off hire" time a quick installation of the trial plant has to be achieved. This is provided by wide hatches and a bright spaced engine room. The trial plant will be installed on platform deck No. 2 behind the main engine nearst to all ship based facilities like electricity, black and grey water tubes and the oil filtering equipment. The location is beside the exsisting conventional sewage treatment system which will be used as mixing and equalisation tank for black and grey water. The treatment of bilgewater will be eased by using an exsisting sewage tank as a buffer for the 15 ppm bilgewater coming from the oil filtering equipment. The buffer will be connected to the trial plant by an dosing pump which makes it possible to treat the bilgewater in doses fitting to the hydraulic capacity of the trial plant.
For the fine tuning, concerning the design and the construction concept of the trial plant a detailed examination will be carried out in September 2001. During the voyage from Vigo to Algeciras raw sewage samples will be taken from black, grey and bilgewater to examine the concentration of the several polluants.

Trial on board TRANSEUROPA

Last but not least the RoPax ferry TRANSEUROPA is designated to be equipped with a MEMROD® reactor. The trial plant will be located on the 2nd cargo deck on starbord. To assure access to safety equipment, the plant will be installed about 2.5 m above the baseline of the deck. Though the types of sewage are comparable to those on board the other ships, the design and construction of the trial plant is considerable more complicated. Because of her special ferry structure, TRANSEUROPA has a port and a starbord section which are separated by the cargo decks located midships. Each section is equipped with a grey water tank and other sewage facilities so that special problems in collecting and piping of the sewage have to be solved. Furthermore there are special security recommendations in the area of the cargo decks for fire protection and because of explosion hazards. According to these recommendations the trial plant has to be carried out in a hermetic closed container. Based on the results of the examination a sampling campaign was carried out in August 2001. During a journey from Lübeck to Helsinki several sewage samples of black, grey and bilge water were taken to get more informations about the essential polluants. Table 4 provides a view to some results of the sampling campaign.

Table 4 Selected results of sewage sampling in August 2001

Parameter		Black water	Grey water with galley
COD	[mg/l]	4,100	1,700
BOD_5	[mg/l]	up to 1,500	650
Fat	[mg/l]	10	400
Organic Nitrogen	[mg/l]	up to 1,000	35

Current Projects

In view of the very good results obtained during the test operation of the MEMROD® LT reactor (reactor operation without pre-cleaned bilge water) on the submarine tender "MEERSBURG", the „German Federal Office for Military Technology and Procurement" decided to equip the Sailing Schoolship "SSS GORCH FOCK" with such a reactor as part of a programme to extend the ship's service life by a further 25 years.

Fig. 2 Process Flowsheet of Wastewater Treatment Plant for "SSS GORCH FOCK"

The wastewater treatment facility on the ship treats the wastewater from the 230 crewmembers. The galley wastewater is pre-treated in a flotation stage and subsequently mixed with black and grey water in a mixing and equalisation tank. The black water is collected in a vacuum unit before it is fed to the wastewater treatment plant. The effluent figures do not only meet the IMO specifications, but are usually significantly better.

Project Data:

• Crew:	230	People
• Wastewater volume:	34.5	m^3/d
• BOD_5 load:	21	kg/d

Required effluent values (according to IMO):

• BOD_5:	≤ 50	mg/L
• Suspended solids	≤ 50	mg/L
• Faecal coliforms:	≤ 250	mL^{-1}

Expected effluent values:

• BOD_5:	≤ 15	mg/L
• Suspended solids:	Not detectable	
• Faecal coliforms:	Not detectable	

As well as "GORCH FOCK", the new Research and Trial Vessel "W.F.E.S. 751" will be also equipped with a MEMROD® LT reactor.

Fig. 3 Process Flowsheet of Wastewater Treatment Plant for "W.F.E.S. 751"

List of frequently used symbols and abbreviations

Abbreviation / Symbol	Meaning	Unit
BMB+F	Bundesministerium für Bildung und Forschung (Federal Ministry for Education and Research)	
BOD_5	Biochemical oxygen demand in 5 days	mg/l
BWB	Bundesamt für Wehrtechnik und Beschaffung (German Federal Office for Military Technology and Procurement)	
CO_2	Carbon dioxide	
COD	Chemical oxygen demand	mg/l
GAUSS	Gemeinnützige Gesellschaft für Angewandten Umweltschutz und Sicherheit im Seeverkehr mbH	
IMO	International Maritime Organisation	
CFU	Colony-forming units	-
MEMROD®	Membrane Reactor Operation Device	
pH value	pondus hydrogenii, negative decadic logarithm of the hydrogen ion concentration in an aqueous solution	-
DS content	Dry substance content	g/l
WABAG-SMS	WABAG Submerged Membrane System	
WBI	Dr. Weßling Beratende Ingenieure GmbH	

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E. Edom, H.-J. Rapsch, G. Veh	Reinhaltung des Meeres, nationale Rechtsvorschriften und internationale Übereinkommen, Hannover 1986
M. Finner, O. Petersen, S. Richter	Entwicklung einer Anlagentechnik für die Reinigung von Schiffsabwasser durch die Verfahrenskombination Belebungsbiologie/ Mikrofiltration, Gemeinsamer Sachstandsbericht zum BMBF-Forschungsprojekt MEMROD 2000
Helsinki Commission	Cover Letter for the Distribution of the Study „Discharge of Sewage and Gray Water from Passenger Ships in the Baltic Sea Area“, 20. Sizung des Maritime Committee, Estland 1994
A. Kraft, U. Mende	Niedrig-Energie-Membranverfahren mit getauchten Membranen für Abwasser-/ Prozesswasserreinigung und –recycling, aus: Möglichkeiten und Perspektiven der Membrantechnik bei der kommunalen Abwasserbehandlung und Trinkwasseraufbereitung, 1. Aachener Tagung 1997
N.N.	Internationales Übereinkommen von 1973 zur Verhütung der Meeresverschmutzung durch Schiffe in der Fassung des Protokolls von 1978 (MARPOL 73/78)

Pictures:

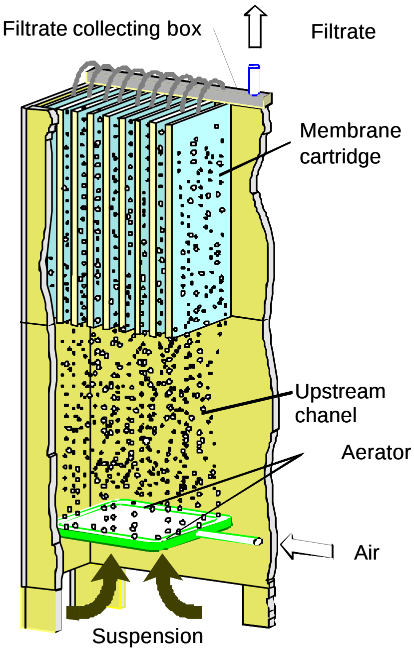


Fig. 1 Membranerack

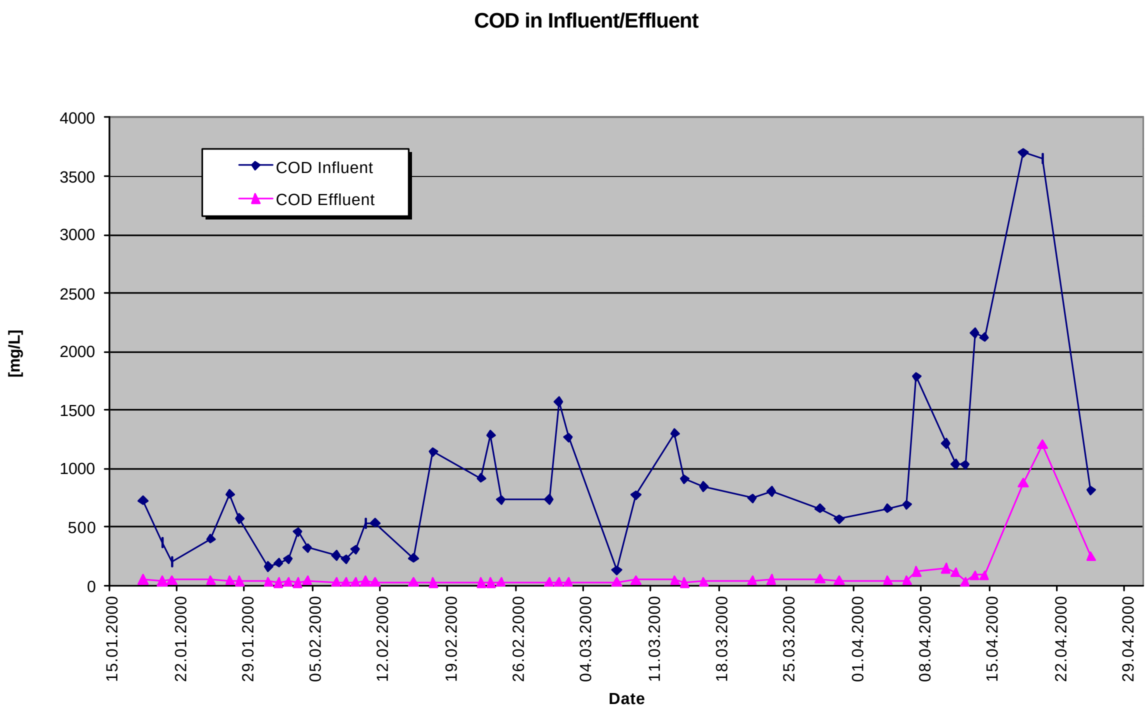


Diagram 1 COD Influent and Effluent Values

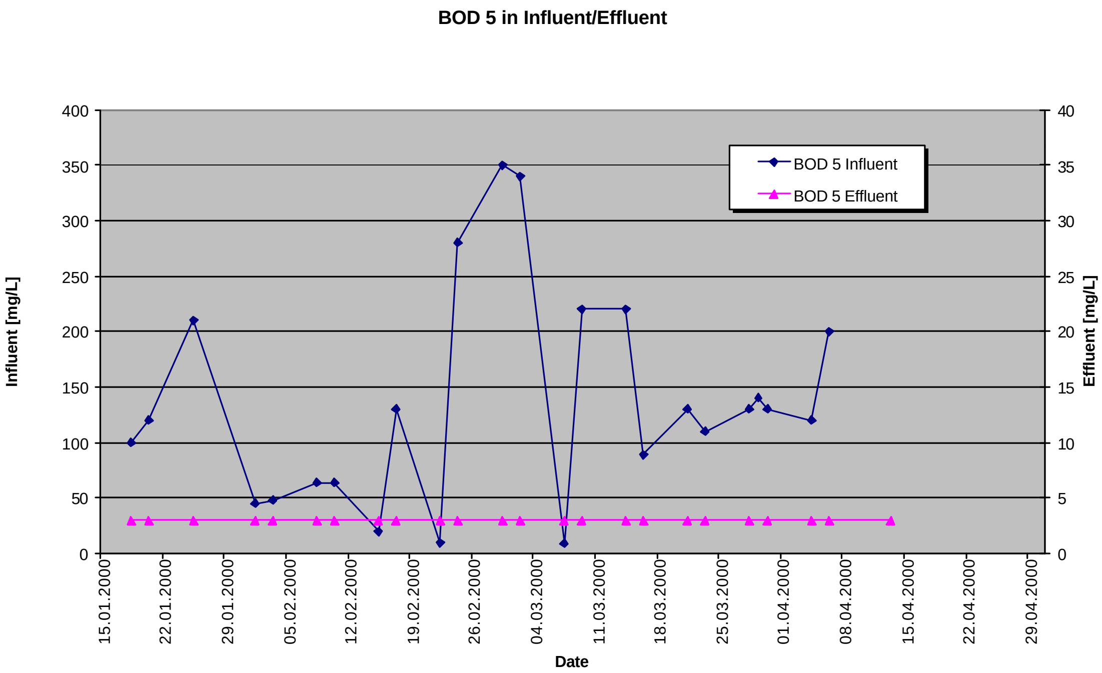


Diagram m 2 BOD_5 Influent and Effluent Values

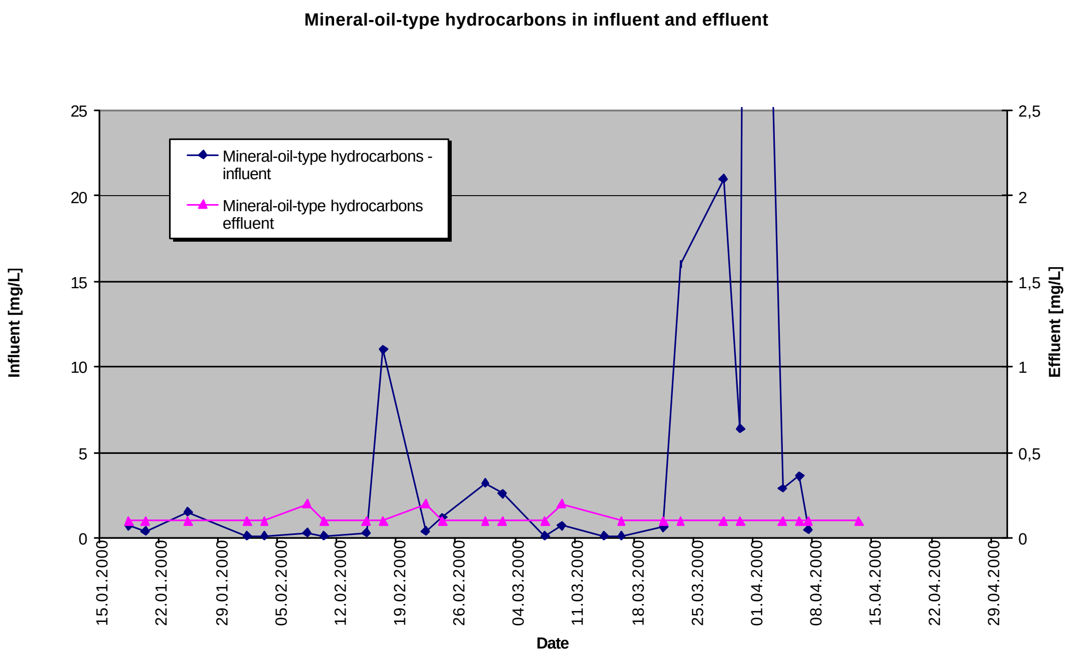


Diagram 3 Mineral-oil-type Hydrocarbons in the Influent and Effluent

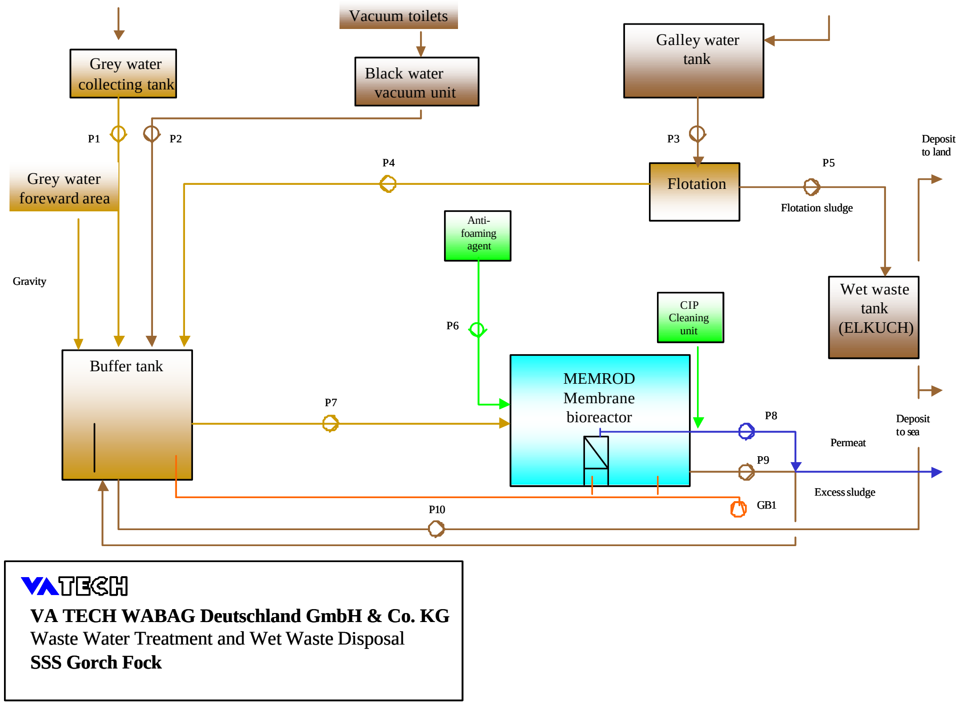


Fig. 2 Process Flowsheet of Wastewater Treatment Plant for ”SSS GORCH FOCK“

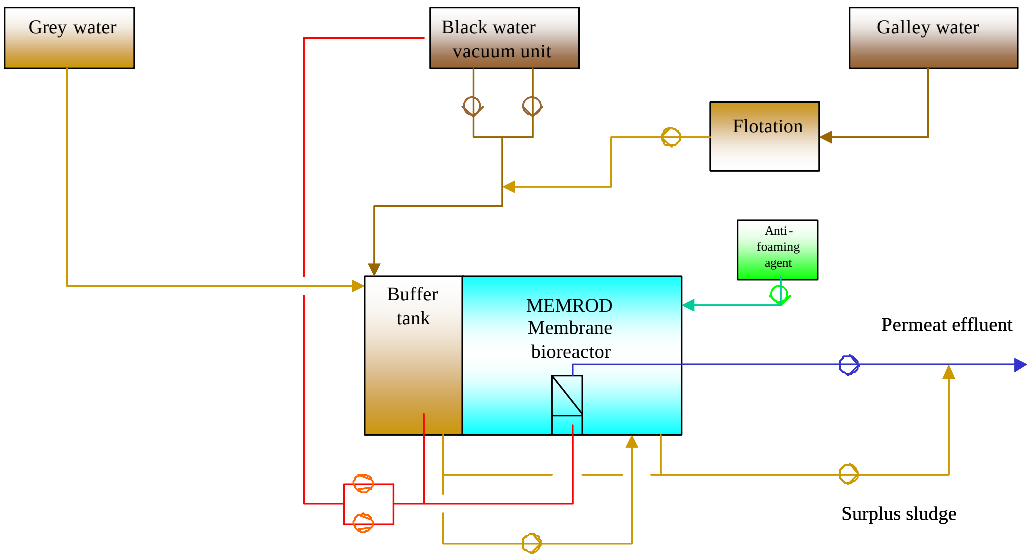
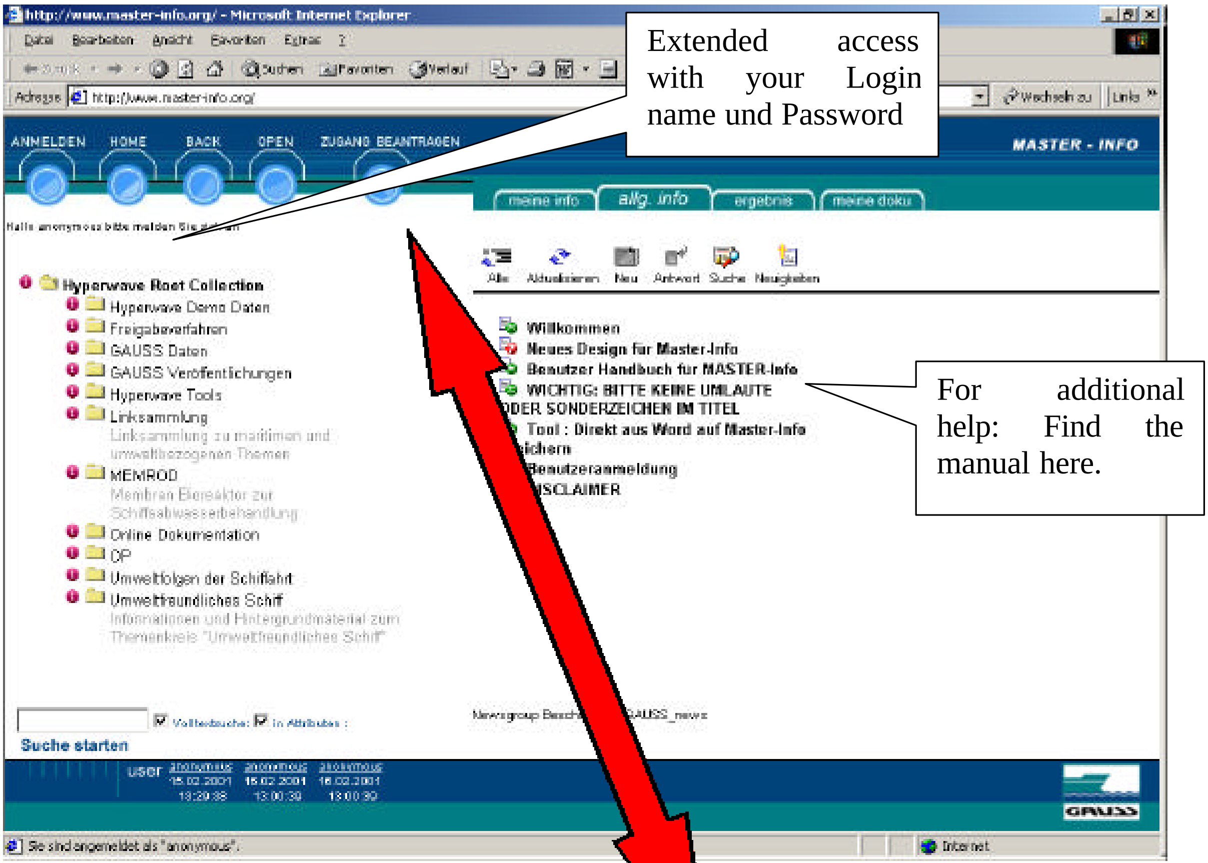


Fig. 3 Process Flowsheet of Wastewater Treatment Plant for ”W.F.E.S. 751“

Sheet 1: Discription of MASTER Info by screen shots



To get the full functionality of Master-Info, you have to register by Click on the button

„Zugang beantragen“

After completion the window

„Account beantragen“

close with a click on the Button

„Account erstellen“

It goes without saying that the registration at and use of Master –Info is free of cost.

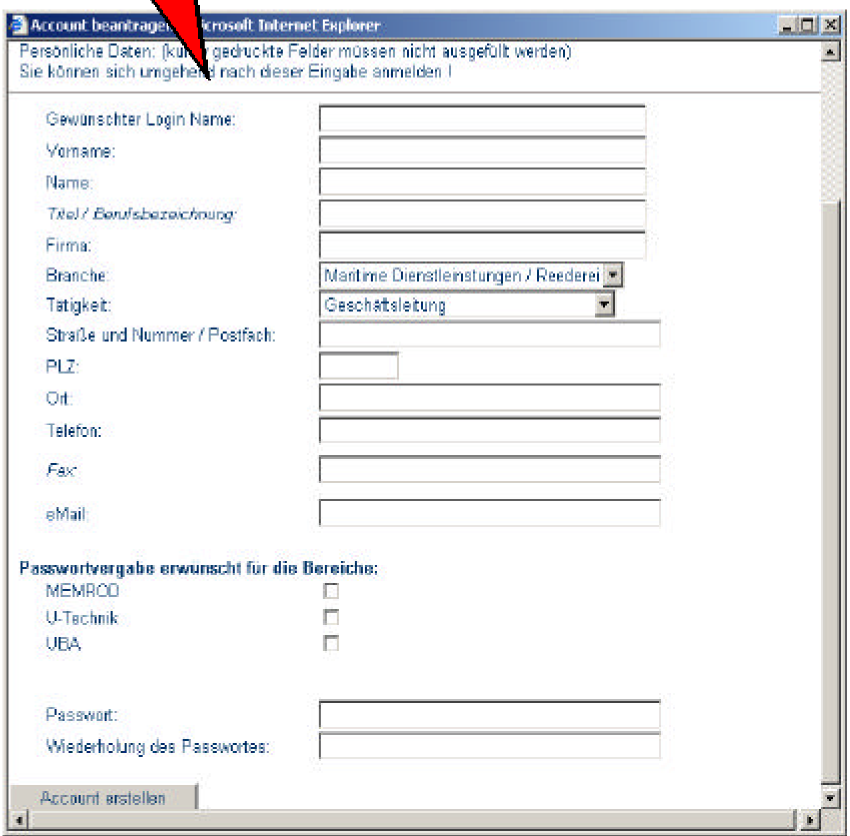
At your next call at MASTER-Info please log in via the button

„Anmelden“

with your **Login name**

and your **password**,

so you will have extended access.



CURRICULUM VITAE

Manuel Finner, Diplom-Ingenieur Chemical Engineering

Born 25th December 1966

- Start of engineer career as a student in 1987. Diploma “Diplom-Ingenieur Chemical Engineering” in 1991.
- Employee of Dr. Weßling Laboratories as project manager since 1991 until 1997.
- Project manager and customer consultant in several questions of water and sewage analyses as well as water and sewage technology.
- Manager of the environmental sample division with six employees carpool and several sampling equipment
- Account manager for customers in the areas housing water supply, sewage treatment and German Army.
- Since 1997 employee of the Dr. Weßling Beratende Ingenieure GmbH
- Independent consultancy in the fields of water and sewage technology. Assessment and evaluation of environmental data and planning for customers in the private, industrial and public sector.
- Manager of several R & D projects in the areas housing water supply as well as sewage treatment on board deep sea ships, founded by leading German research institutions.
- Member of the Association of Housing water engineers (DVGW/DELIWA), the Association of German engineers (VDI). Member of the working group "Protection of the Marine Environment", as well as of the working group “Water supply and sewage treatment, Bureau for Standards of Maritime and Ships Technique (NSMT) within DIN and member of the ISO/TC 8/ sub-committee 2 "Marine Environment Protection".
- Today division-manager “sewage and chemical engineering” of Dr. Weßling Beratende Ingenieure GmbH.

Manuel Finner
Altenberge, July 2001

CURRICULUM VITAE

Olaf Petersen, MSc Maritime Engineering

Born 30. July 1963

- Start of seafaring career as cadet in 1985, further career until 1999 with Maritime Engineer Officer's certificate in 1990 and diploma Diplom-Ingenieur Schiffsbetriebstechnik simultaneously.
- Employee of several German shipping companies onboard German flag container vessels, with positions as technical officer and Second Engineer.
- Scientific work for the German Environmental Protection Agency (Umweltbundesamt), in the field of Ships waste handling, processing and disposal.
- Author for german seamans welfare publications (up to date No. 52 “Umweltschutz an Bord).
- On-site manager and project engineer with a german waterconstruction company.
- Consultancy and implementation in the field of managementsystems (ISO 9000 ff, ISM-Code).
- Independent consultancy in the field of offshore waste management, *inter aila*, sub contractor of GAUSS.
- Member of the Association of Marine Engineers (Verein der Schiffs-Ingenieure zu Hamburg), the Association of German engineers (VDI) workinggroup “business management and sales/distribution”, Member of the working group "Protection of the Marine Environment", Bureau for Standards of Maritime and Ships Technique (NSMT) within DIN, and member of the ISO/TC 8/ sub-committee 2 "Marine Environment Protection", Member of German Sailing Association (DHH).
- Today project-manager of GAUSS.

Olaf Petersen
Bremen, Januar 2000

CURRICULUM VITAE

Dipl.-Ing. Dr.-Ing. Thomas A. Peters.

- Born 31.03.1947 in Berlin; grew up in Barcelona, Spain.
- Diplom-Ingenieur (MS) of chemical engineering, Technical University of Clausthal, Germany.
- Dr.-Ing. (Ph.D.) thesis: desalination of sea water with reverse osmosis, University of Erlangen-Nürnberg.
- 1980 to 1986: head of the department “reverse osmosis” of a middle sized water treatment company and later director of research and development of the water treatment division of a large concern
- Since 1986 independent consultant for membrane technology and environmental engineering, advising manufacturer, plant operator, contractors, communities, authorities and governmental institutions

Abstract

Dr. Thomas Peters, Rochem UF, GE

"The Maritime Environment"

" ROCHEM Technologies for Waste Water Treatment on Cruise-Liners for Newbuildings and for Retrofit".

ROCHEM likes to introduce their advanced technology for black and grey water treatment on ships, specifically an cruise ships, to provide the protection for the marine life by cleaning the waste water to such extend of purity, that the effluent discharged will meet the **Miami Dade County limits** for discharge to surface water within coastal areas or ports.

The concept of ROCHEM results to an **"Environmentally Sound Ship"** and allow the owner to install such technology just on their new building under construction or as well as a retrofit, based on the very flexible modular, sectional mounted treatment system, to meet even difficult space locations.

One of the main feature of the treatment concept is the ROCHEM Bio-Reactor Type "BIO-FILT", suitable to treat all black water and the grey water of high organic loads as a **"State of the Art"** Technology. The process offers the design features of an fast reacting, high efficient process with high bio mass density, combined with membrane filtration. The BIO-FILT is proving a fully controlled biological process, which allows a high BOD degrading in relation to small process volume, saving a lot of space for the total equipment as a great advantage, specifically for retrofit.

The own patented "ROCHEM FM- Membrane Module" configuration allows the operation of such MBR Membrane Bio-Reactor with high grade on availability and reliability and constant performance.

ROCHEM has supplied such complete processing concept/systems to new buildings and for retrofit on cruise liners and on other type of ships.

GREY WATER PURIFICATION AND BLACK WATER TREATMENT ON BOARD CRUISE SHIPS WITH ROCHEM TECHNOLOGY

Dr. Thomas A. Peters
Dr.-Ing. Peters Consulting for Membrane Technology and Environmental Engineering

i.b.o.

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ABSTRACT

Growing environmental pollution, tightened discharge regulations and rising costs for waste handling in ports are the driving forces for the development of solutions for the waste water treatment on ships. The solution offered by ROCHEM for the waste water management on board cruise ships is based on different processes for different kinds of waste water. The purification of grey water is achieved with low pressure reverse osmosis using the FM (Flat Membrane) module. Black water is treated in the membrane bioreactor Bio-Filt®, a combination of a high cell density reactor with the FM module system for ultrafiltration. The complete retention of the biomass with ultrafiltration leads to a high biomass concentration in the reactor and a highly efficient biological reaction process with reduced sludge production, insensitivity to both high loads of contaminants and changing peak loads, as well as, a safe and controlled separation of bacteria, viruses and parasites due to the ultrafiltration membrane that operates as a barrier. Additional advantages of both systems are small foot-print and economic operation even for small decentralised plants. Thereby, the combination of open channel construction and narrow gap technology of the FM-module with a very efficient cleaning method allows for high filtrate fluxes with low energy demand. These concepts and plants developed by ROCHEM for the purification of grey water and the treatment of black water on board cruise ships are presented.

1. WASTE WATER DISCHARGE OFF-SHORE

The growing concern in recent years around the world regarding environmental pollution, the anticipation of tightened global waste water discharge regulations, and the rising costs for waste handling in ports are the main driving forces for the development of solutions that could contribute to a "green ship concept" or an "environmentally sound ship".

The high amount of waste water discharged overboard due to increased numbers of passengers ranging from 1000 up to 5000 on cruise ships and ferries causes severe danger to the environment. In most cases, the effluent is still not treated and there is usually a large rate of chlorine used to disinfect the effluent before passing it overboard. In ports the waste water is left in holding tanks with limited capacity.

These problems can be resolved by treating such waste water with processes based on ROCHEM's FM module system. For the purification of grey water, low pressure reverse osmosis membranes are used. Black water and galley water are treated in the membrane bioreactor Bio-Filt®. Bio-Filt® is a combination of a bioreactor with the FM module equipped in this case with ultrafiltration membranes

2. WASTE WATER MANAGEMENT ON BOARD CRUISE SHIPS

ROCHEM´s concept for waste water management on board cruise ships and the corresponding plants have been developed in order to meet the following goals:

- black and grey water treatment plants with compact construction
- high process stability despite changes in salinity and COD/BOD_5
- high efficiency
- high cell density in the biological treatment
- simple adaptation to different hydraulic demands
- insensibility to alternating loads
- rejection of bacteria and viruses
- reuse of the purified water

Based on the experience gained with the purification of industrial waste water for many years (ROCHEM has been working in the field of reverse osmosis since 1982) and in order to guarantee an operation that is economic, safe, and meeting the legal requirements, the plants have been designed with consideration for the following conditions:

- treatment of different kinds of waste water with adapted technologies according to the principle "do not mix!"
- use of a good pre-filtration in order to separate larger solid matter and to relieve the treatment process itself
- ability of ultrafiltration membranes to separate from the waste water stream all kinds of particulate components including bacteria, viruses and parasites
- ability of reverse osmosis membranes to separate from the waste water stream all kinds of dissolved organic and inorganic components based on rejection rates up to 99%

Consequently ROCHEM plants in operation on board several cruise ships have been delivered as complete solutions for different kinds of waste waters based on modular systems composed of:

a) pre-filtration with an automatic self cleaning filter with low maintenance requirements and low water content in the removed solids;
b) low pressure reverse osmosis (1 or 2 stage systems) for the grey water purification;
c) combination of bio-reactor and membrane technology (ultrafiltration) for the black water treatment (Bio-Filt®);

d) submerged vacuum module (SV module) for the dewatering of the excess sludge.

The ROCHEM plants for low pressure reverse osmosis and the membrane bio-reactor Bio-Filt® are equipped with the FM module.

3. FM OPEN-CHANNEL MODULE

High economy, process stability, and safe function can be achieved for the operation of membrane plants only if resistant membranes are combined with a modus operandi that is adapted to the specific demand, in combination with membranes and a membrane module configuration that is selected to meet the requirements of each problem. In this respect, the FM (Flat Membrane) module system (Figure 1) has proven itself to be very efficient /1/.

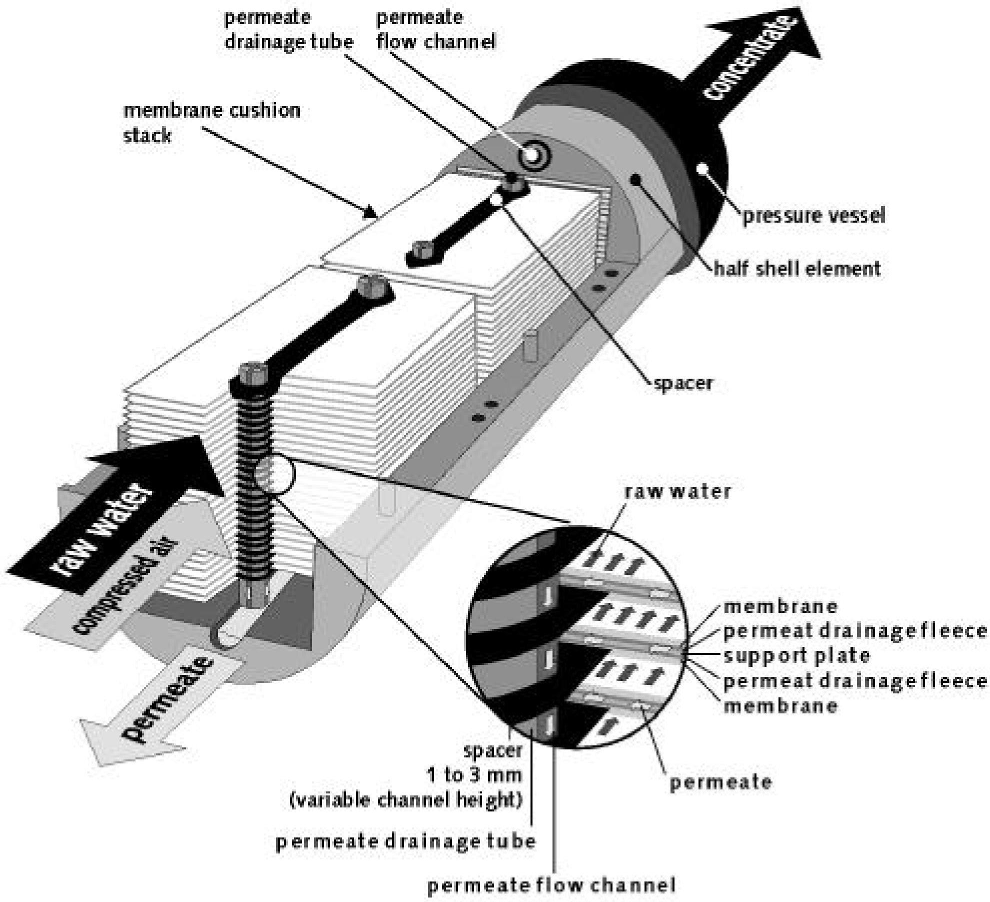


Fig. 1: FM (flat membrane) module Source: ROCHEM

The FM module system has been developed for the separation of bacteria and particles from waste water with a high fouling potential using ultrafiltration. In addition this module is successfully used for different applications of the membrane processes for nanofiltration and low pressure reverse osmosis. The module allows for a low energy demand and high constant permeate flux rates. The construction of the membrane cushion elements permits the use of this system for extremely diverse types of polluted water, since channel heights can be changed by altering the thickness of the spacer. The construction material and the modus operandi can also be selected.

According to the patented construction, the FM module is a module with membrane cushion elements with open raw water channels. No spacers are needed between the membrane cushions. Performance-lowering flow deflections are eliminated by connecting the membrane cushion elements in series.

The fundamental concept of the FM-module system is based on the combination of open channel construction and narrow gap technology. On the one hand, the open channel ensures that the membranes are able to be cleaned efficiently. This is a basic requirement for trouble-free operation with long-lasting reproducible high performance with regard to rejection rates and permeate production. On the other hand, the hydraulic conditions and the narrow gap minimise the specific energy demand, resulting in a very economical operation. Water with high particle concentrations can be treated yielding high recovery rates due to the special construction of the flat channels and their capacity to handle feed with high suspended solids loads.

The advantages of this module can be summarised to be:

- open channel design (up to 3 mm)
  ‣ high TSS (total suspended solids) concentration at low pressure drops

- wide range of membranes (different materials and/or Molecular Weight Cut Off)
  ‣ choice of the membrane according to the waste water to be treated

- easy adjustment of the module size to different hydraulic demands
  ‣ flexibility

- mechanical and hydrodynamic chemical-free cleaning of the module during normal operation

- less frequent chemical cleaning
  ‣ low operating costs

4. PURIFICATION OF GREY WATER WITH LOW PRESSURE RO

The system for the purification of grey water according to ROCHEM´s concept for a water management based on different quality requirements is shown in Figure 2.

The plants are delivered as standardised factory tested units, modularly constructed in sections with feed capacities from 6 to 650 m3/d, offering fully automatic operation, simple handling and low maintenance requirements.

The type of the grey water purification plant shown in Figure 3 has a capacity of 600 m^3/d. Plants of this size are in operation since February 2000 and March 2000 on the

“MERCURY” and “GALAXY”, operated by Celebrity Cruises. The classification society is Germanischer Lloyd, IMO Type II.

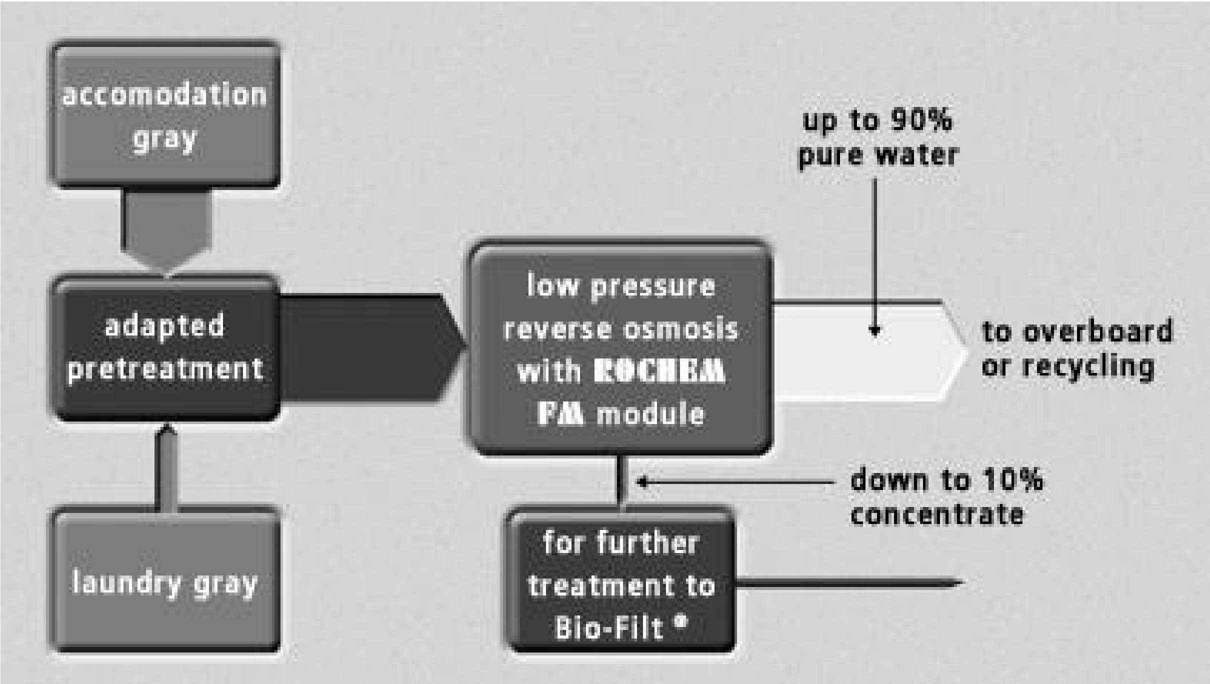


Fig. 2: ROCHEM´s concept for grey water purification

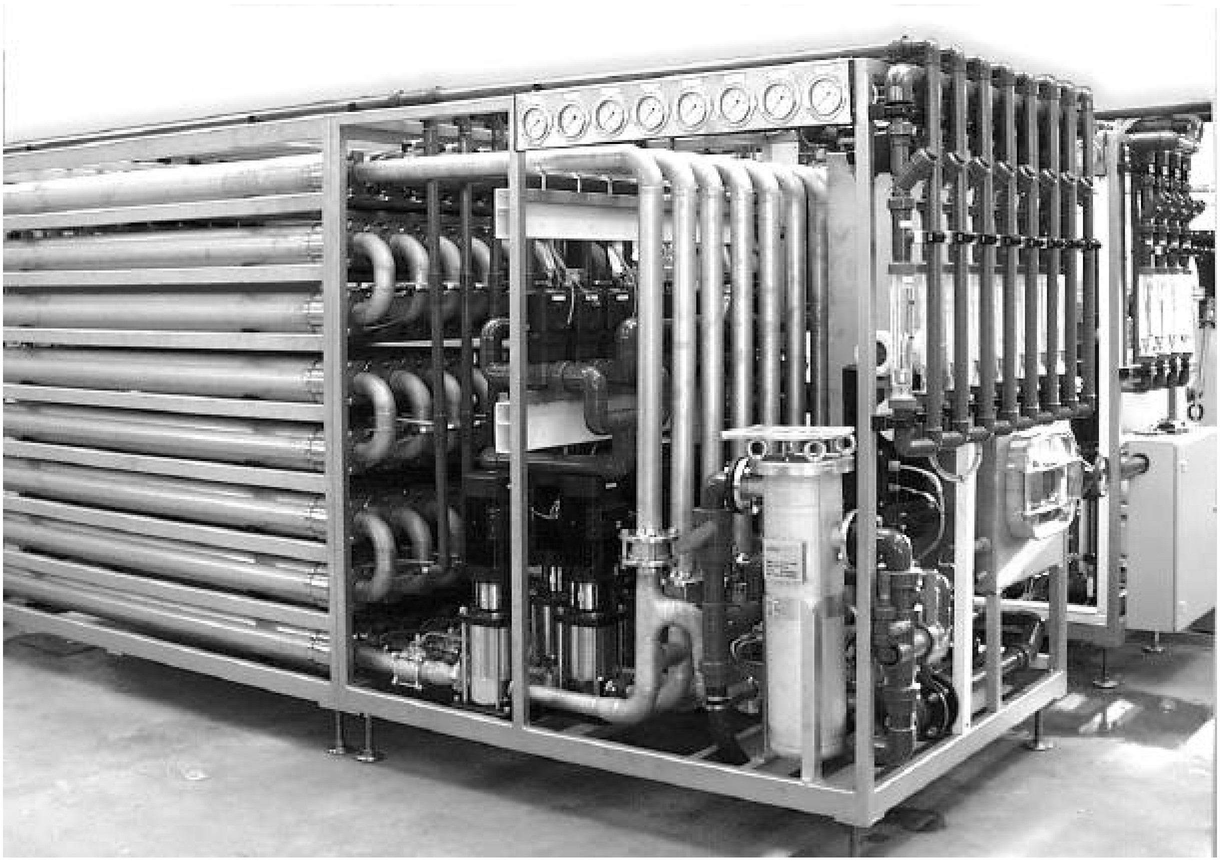


Fig. 3: low pressure reverse osmosis plant for grey water purification

The module configuration assures a high reliability and filtration performance with a high degree of purification. No chemicals or disinfectants will be necessary for achieving a pure effluent which can be reused as technical water (toilet flushing and boiler feed water) or discharged overboard at any location. Up to 90% pure water recovery can be achieved.

This solution helps to overcome:
- the limitations for operation in domestic and foreign waters due to waste water regulations,
- the limitations regarding shipboard space and weight constraints, and
- the limitations for tightening discharge standards or varying state regulations.

At the same time, this technology helps to avoid:
- high costs of waste handling in domestic and foreign ports
- expenditures for handling, storage and dosage of disinfection chemicals.

5. TREATMENT OF BLACK WATER - MEMBRANE BIOREACTOR Bio-Filt®

Black water is characterised by a high content of organic matter. Very elevated values for suspended solids, uncountable numbers of microorganism like faecal bacteria and high values for the biochemical oxygen demand (BOD) show that this liquid waste is very harmful for the environment. It has to be treated to meet the wastewater discharge standards.

Conventional biological wastewater treatment relies on large aeration tanks. However space and weight are limiting factors for the installation of such systems on ships. The solution to this problem is the membrane bioreactor, Bio-Filt® (figure 4), developed by ROCHEM based on its experience with on board and offshore related water treatment technology since 1982 /2,3/.

The combination of a biological reactor, that is operated with a high cell density and biomass in the range of 15 to 25 g/l, with the FM module equipped with ultrafiltration membranes (figure 5) can achieve high ratios of biological degradation. Since the ultrafiltration membrane acts as a barrier and rejects all bacteria and all kinds of suspended solids, the disinfected effluent meets every discharge standard - similar to or better than land based plants. The effluent is so pure, that it can be discharged overboard anywhere or even used for technical applications on board.

The membrane bioreactor Bio-Filt® is IMO certified and meets MIAMI DADE COUNTY requirements. Achievable results are:

- TSS < 5 mg/l (n.d. = non detactable)
- fecal coliform < 10 MPN/100 ml
- BOD < 20 mg O2/l

Because of the high biomass concentration in this membrane based reactor, the high ratio of space loading, and the large sludge reaction time, the production of sludge is reduced up to 80% in comparison to conventional systems. The high biomass also is the basis for the insensitivity of this system to high loads of contaminants and changing peak loads.

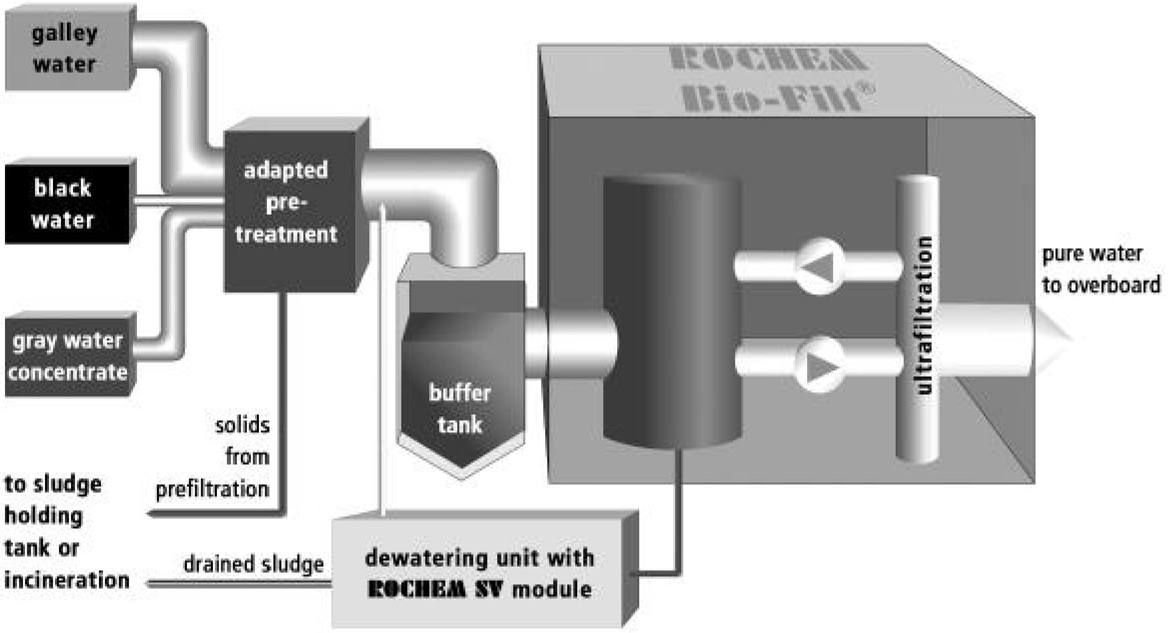
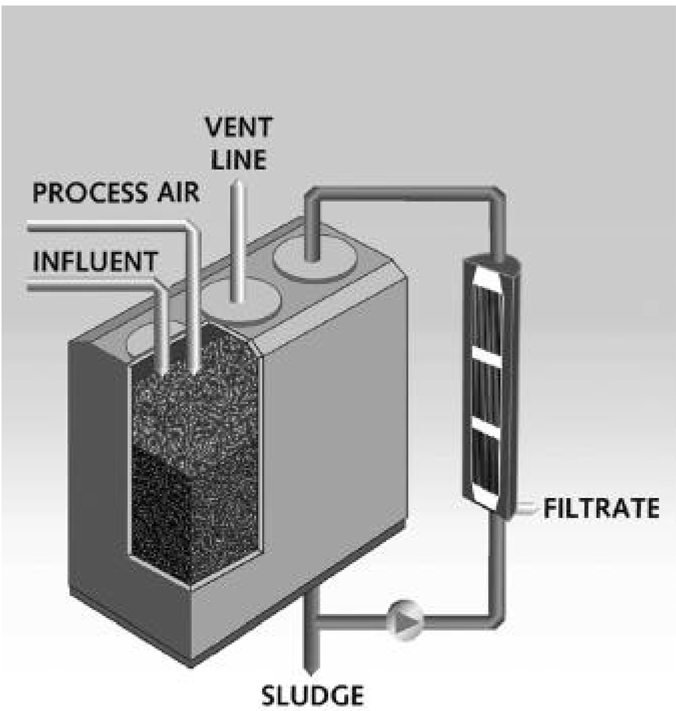


Fig. 4: ROCHEM´s concept for black water treatment



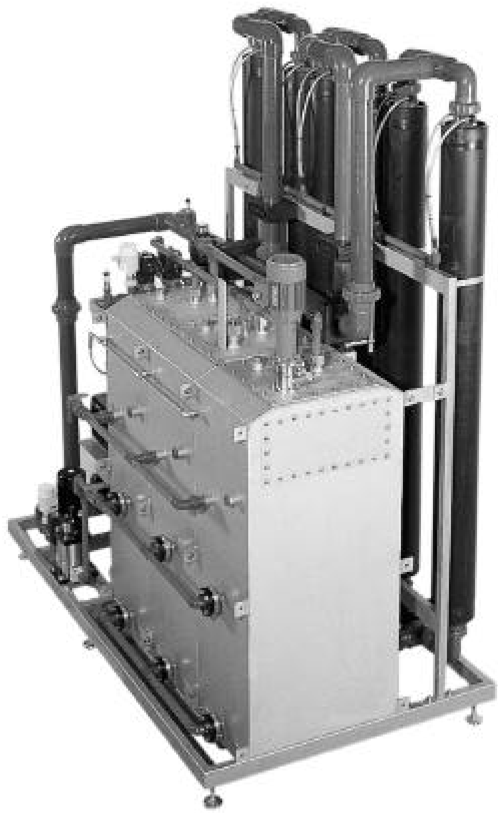


Fig. 5: membrane bioreactor Bio-Filt® - design and plant with 3 segments

The modular design allows for low space demand and an economic operation even for small decentralised plants.

The plants prevent the emission of odour since they are manufactured as closed loop and capsulated systems. The technology itself helps to avoid the discharge of chlorine or harmful or hazardous chemicals to the environment.

6. FEATURES OF ON BOARD WASTE WATER TREATMENT PLANTS

In summation, it can be stated, that the plants for the purification of grey water and the treatment of black water on board cruise ships have been developed by ROCHEM according the requirements of an environmentally sound ship. It is a contribution to the green ship concept that can be installed on all ships, including ferries, merchant, naval and yachts.

The main features include:

- affordability: low operating costs, standardised systems
- adaptability: designed for both new-buildings and retrofits
- compactness: minimised space and weight, pre-wired and pre-piped
- efficiency: long operating intervals due to open channel technology with efficient flushing/cleaning
- flexibility: independent stand alone units, adaptable to incremental demand
- reliability: approved technology with high availability
- safety: ultrafiltration membranes are operating as a barrier against particles, bacteria, viruses, parasites

7. CONCLUSIONS

The concept for the purification of grey water and the treatment of black water developed by ROCHEM is based on the FM module system fitted with low pressure reverse osmosis membranes and ultrafiltration membranes, respectively. Another cornerstone of this successful solution is the strict separation of these waste water streams and an efficient pre-filtration.

The purification of grey water is achieved using low pressure reverse osmosis. The black water is processed in the membrane bioreactor Bio-Filt®, a combination of the FM module with ultrafiltration membranes and a bioreactor of modular design, manufactured with multi-tank construction. This system for the improved purification of waste water can be easily adapted to different applications. The open channel construction and narrow gap technology realized in the FM-module and the very efficient rinsing and cleaning method developed for this module are the basis for the reliable function of the waste water purification process and the operating safety of this combination of membrane and bioreactor technology.

Low energy demand and high availability of ROCHEM´s technological approach lead to an economic waste water purification process with small installation space that can help to reduce the negative impact to the environment of waste water discharged from ships.

It may be mentioned, that the company received the SEATRADE AWARDS 1998 and 2000 in the category „Countering Marine Pollution“. The technology is claimed to meet the requirements regarding the items:

- preservation of our environment
- protection of our resources
- safeguarding our future

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/1/ Peters, Th.: Improved water and waste water purification with the DT-UF module. UTA TECHNOLOGY & ENVIRONMENT, International Edition, 4 (1998)

/2/ Guttau, S., Günther, R.: Abwasseraufbereitung mit Bioreaktor und Ultrafiltration. SPEKTRUM, Technische Universität Hamburg Harburg, Sommersemester 1999

/2/ Peters, Th., Günther, R., Vossenkaul, K.: Membrane bioreactors in wastewater treatment. Filtration + Separation, January/February 2000

CURRICULUM VITAE

Allan Smith BSc, C Eng, M I Mech E

Graduated in mechanical engineering from Leicester University in 1967, as part of a professional engineering training programme operated by the British Steel Corporation.

Initial appointments were within British Steel, developing steel manufacturing processes, specialising in the hydraulic control of machinery.

Joined the Hamworthy Engineering Group in 1971, initially as a design engineer and then as chief design engineer for centrifugal pumps. Has since worked for the Hamworthy Group in a number of different roles, mostly associated with marine engineering, product design, customer relations and quality assurance, and is currently Engineering Manager for HamworthyKSE Marine and Offshore. Most recently has had a special interest in finding improved solutions to the problems created in disposing of waste materials generated on board ships, and in particular the liquid wastes.

Mr. A. E. Smith

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Abstract

Allan Smith, Hamworthy KSE, UK

"The optimisation of membrane bioreactor technology for use in the treatment of marine waste water"

Summary:
The Hamworthy Group has been a major supplier of treatment systems for waste water generated on ships for more than 25 years. A continuing product development programme, directed by the demands of the marine market, and by the availability of new technologies, has led to significant advances in the standards of waste water treatment that can be achieved.

This paper describes the development of a combined high rate bioreactor and membrane separation system, capable of handling a range of alternative profiles of waste water input, and of producing consistent high quality effluent. A programme of conversion for an in-service cruise ship is described, with comments on operational experience.

In preparing this paper the author wishes to acknowledge the co-operation and assistance of P&O Cruise Line staff.

“The optimisation of membrane bioreactor technology for use in the treatment of marine wastewater”

Allan Smith BSc, CEng, MIMechE
Engineering Manager, Waste Treatment Systems, HamworthyKSE

Allan Bentley BSc, CEng, MRINA, MIMarE
Managing Director, HamworthyKSE

Summary:

The Hamworthy Group has been a major supplier of treatment systems for waste water generated on ships for more than 25 years. A continuing product development programme, directed by the demands of the marine market, and by the availability of new technologies, has led to significant advances in the standards of waste water treatment that can be achieved.
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In preparing this paper the author wishes to acknowledge the co-operation and assistance of P&O Princess Cruises staff.

1. Introduction

I expect that most of the people here today will be aware of the Hamworthy Group as a supplier of marine equipment. The group has a multiproduct capability, dedicated to the supply of specialist equipment for the marine industry. Many of our product groups not only hold positions of technical leadership in their respective market sectors, but are also based on strong historic sales figures and wide application experience. This is particularly the case for wastewater treatment systems, where we have supplied more than 6000 systems over a twenty five year period.
Our close contacts with operators of wastewater treatment systems, and the builders and repairers of ships, mean that we are not only aware of the way the equipment is specified to work, but also the real conditions that exist after extended operation. Hamworthy have sought to design equipment that gives high values to ease of operation, product maintainability and consistent achievement of the required performance.
In looking for the optimum solution to a system design problem we are not constrained by a company commitment to any particular technology. We are able to

assess the widest possible range of available techniques, and choose those that are the most appropriate solution to the customer need. There is of course a high degree of expertise within the company in the handling and treating of waste water, supported by academic and commercial in depth specialist knowledge where required.

2. Key agents for change

For waste water discharges there are a number of alternative standards that are either in force or under discussion. A complete discussion of these alternatives would be a subject for a separate paper, however it is apparent that conformance to IMO / USCG historic standards for treated sewage (black water) is not sufficient to meet the expectations of those responsible for regulating some coastal waters.

The demand for cruise ship visits to areas of great natural beauty and plentiful wild life has produced a heightened sensitivity to waste discharges. Monitoring of discharge water quality, and enforcement and penalties in the event of non-conformance to regulations is now the norm for the Alaskan area. We can expect similar action in other coastal waters where regional and national authorities have strong concerns for the protection of the marine environment.

Conformance to the regulatory requirements is not only driven by the penalties that may be imposed by authorities, but also by the strong negative marketing image of publicity following the identification of unacceptable discharges.

3. Definition of the waste water problem

One difficulty in establishing a suitable design of treatment system is to establish a clear definition of the waste water to be treated. Ideally the treatment system should handle the aggregate of black water, sanitary grey water, laundry water and water from galleys, however for some of the waste streams the quality and quantity of the water can vary considerably depending on the system design. Each waste water system needs individual assessment to determine the necessary treatment processes, pre-treatment may be necessary for some waste streams, ie fat and grease removal from galley waste water. Consideration needs to be given to the strength of the waste, to at least define the level of waste degradation and solids removal necessary to meet the required discharge standards.

We have chosen to design the basic process to meet the US standards for discharge of treated waters to inland waters, given in the Code of Federal Regulations Title 40 Part 133.

	Units	IMO	USCG	40 CFR 133
		10 day ave	10 day ave	30 day ave
Suspended Solids	mg/l	50 (100 at sea)	150	30
BOD_5	mg/l	50	Not required	30
Faecal Coliform	count/100ml	250	200	20 (see note)
pH		Not required	Not required	6.0 to 9.0
Chlorine	mg/l	As low as practicable	Not required	10.0 (see note)

Note: Test methods and averages vary in definition dependent upon test authority, Faecal Coliform and Chlorine limits are not part of 40 CFR 133, but additional requirements of the "Murkowski regulation".

With the limits on Faecal Coliform, and Chlorine added into the preceding table the treated water meets the requirements proposed for waste water discharges in the Federal cruise ship legislation section 1404 ("Murkowski regulation"), and the Alaskan State legislation HB 260.

In addition to defining the standard of quality for the primary discharge of treated water any secondary discharges from the treatment system need to be identified, quantified and management / disposal strategies identified. These may include gas / vapour emissions, solid material / screenings with variable moisture content, and primarily liquid / slurry waste. The best option for dealing with each secondary waste will depend on the characteristics of the vessel that the treatment system is installed in. For instance, is there available incinerator capacity to deal with the volume of screenings, is there storage capacity to allow the holding of any generated slurry between discharge opportunities?

There may also be the possibility of using the treated waste water to eliminate some other water treatment requirement, for instance use as compensating ballast, that can be discharged to sea in port areas without the risk of introducing alien species.

4. Assessment and choice of appropriate technology

The wastewater contains a variety of contaminants, some being soluble and others being in a variety of solid forms, and which may be non-biodegradable, or with varying degrees and rates of biodegradability. In selecting a treatment process the ability to handle the complete range of contaminating materials needs to be carefully considered. This is not only from the aspect of generating a treated waste stream in conformance to the requirements, but also the amount and quality of secondary waste, and the reliability of the system when operating with the complete range of contaminants.

There are a wide variety of processes available, some developed to treat municipal or small community wastewater, and others designed to deal with industrial waste streams. Particulate matter may be separated out, using filtration or settling, possibly assisted by dosing with a flocculent agent. Settling can be by gravity, or assisted by a centrifuge or decanter. Chemical processes, using dosing or electrochemical oxidant sources, may be used to convert contaminating material into compounds that may be benign and/or more easily separated from the liquid phase. The most commonly used means of reducing the amount of organic contaminating material is to degrade by aerobic biological action, reducing organic material to principally water and carbon dioxide. In order to achieve the required standards of discharge water quality most practical systems use more than one technique to deal with the range of materials in the wastewater.

Almost all the possible treatment processes require a separation stage, to retain suspended solids within the treatment system. This is a critical choice, as it is likely to be the part of the process that regulates the process capacity. Particularly for the biological treatment processes membrane separation technology has been adopted, generally using low pressure membranes. A full discussion of the merits of the alternative types of available low pressure membranes for use with biological treatment systems would be somewhat lengthy. However it is worth noting the generic types of membrane available, and their applicability to the two principle methods of application:

Membrane type	Method of application	Advantages
Flat sheet	Submerged in tank, air induced cross flow	Low membrane surface turbulence, membranes within dimensions of the treatment tank
	Sidestream in module casings, pumped cross flow	Good membrane surface turbulence, modules can be removed with system in service
Tubular	Submerged in tank, air induced cross flow	Fair membrane surface turbulence, membranes within dimensions of the treatment plant
	Sidestream in module casings, pumped cross flow	Excellent membrane surface turbulence, modules can be removed with system in service
Hollow fibre	Submerged in tank	Poor membrane surface turbulence, membranes within dimensions of the treatment tank

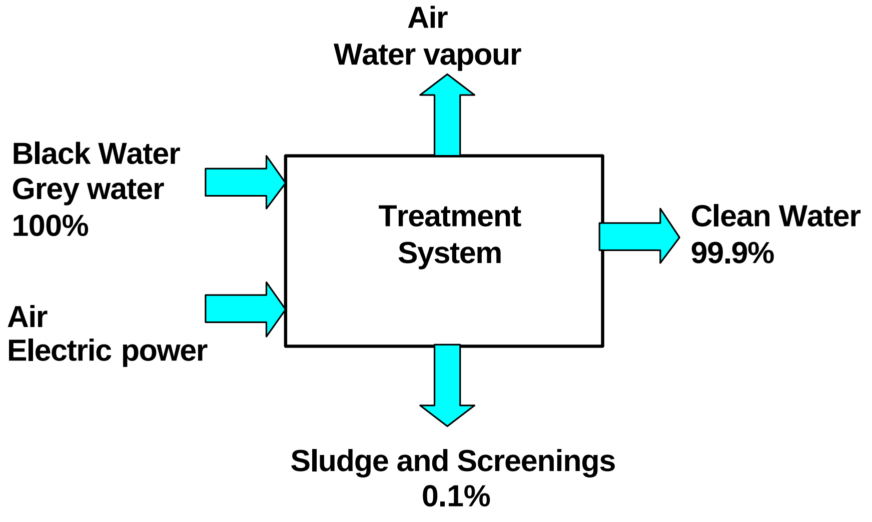
Submerging the membrane in the process tank has the benefit of minimising the volume of the system. However use of membranes in a side stream installation allows better control of surface fouling by turbulence in the cross flow, and allows either insitu cleaning or replacement of membrane modules with the system remaining operational.

5. Hamworthy design

The design team at HamworthyKSE has a high degree of expertise in the design of biological digestion units for wastewater, particularly aerobic digesters. The development of a high rate biological digester, using a physical barrier including a suitable membrane for clarification, is a natural evolution of familiar technology. In addition the extensive experience of marine applications in the team has ensured that design options selected conform to the requirements of shipboard operation.

A bioreactor operating with a biomass suspended solids of around 20 g/l is capable of achieving very significant rates of organic material reduction, measured both as BOD_5 and COD. The rate of organic sludge growth is related to the ratio between the organic content of the incoming flow to the amount of active biomass in the bioreactor. The use of relatively high levels of biomass suspended solids ensures that this ratio is kept low, and the resulting rate of organic sludge growth is also very low.

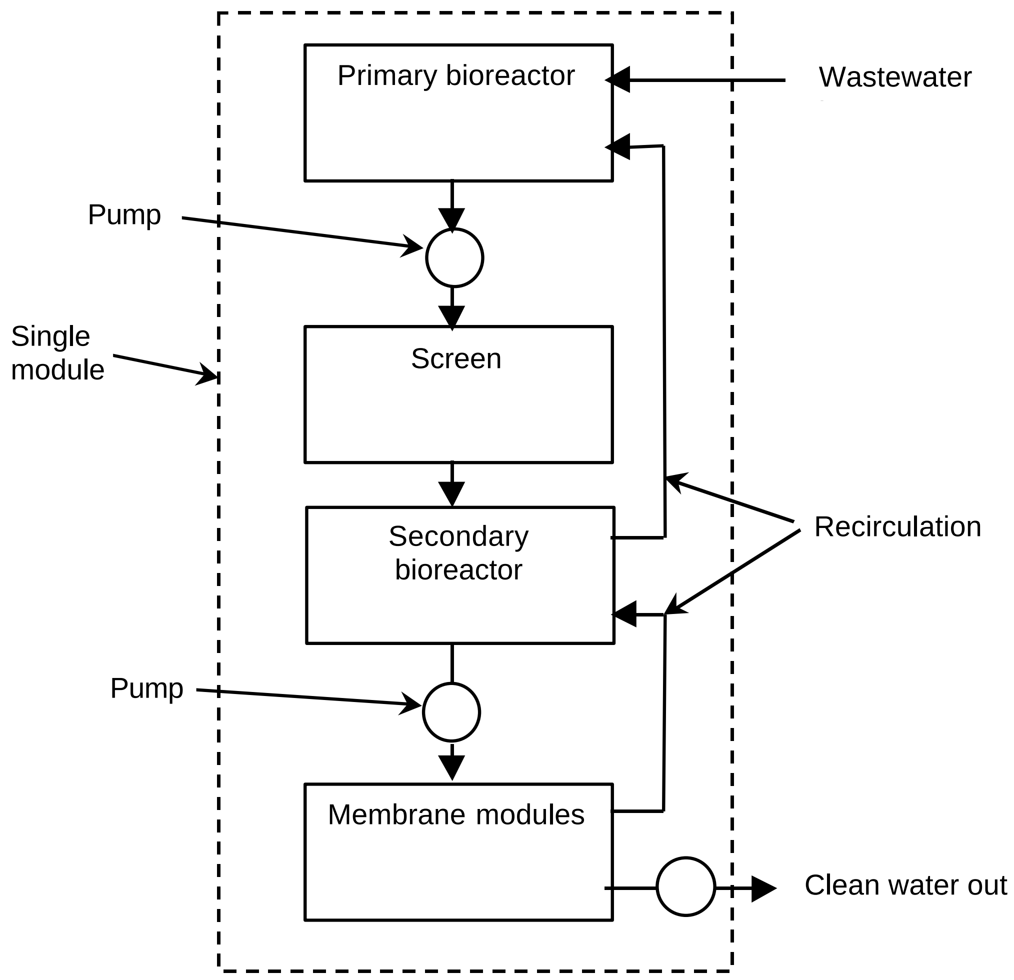
The incoming wastewater also contains non-biodegradable solids (or with very slow rates of degradation), typically plastics, grit, hair, fibres and some types of greases. These need to be removed from the system, by periodic desludging, or by extraction through a suitable screening system.



System Concept

Hamworthy have chosen to use tubular membranes, using 8 mm nominal bore tubes, mounted into 200 mm nominal diameter fibre reinforced casings. The membranes are rated in the ultra-filtration range, with a nominal pore size of 40 nano metres. These are used in side stream mode, with cross flow generated by centrifugal pumps.

Control of non-biodegradable material, or slow to degrade fibrous material, is by self cleaning filter, operating with an aperture size of 200 to 400 micron depending on the application. The system is arranged with a primary bioreactor, operating aerobically and reducing the incoming organic material by the action of the



Simplified system schematic

concentrated biomass, with a self cleaning filter in the transfer to a second stage reactor. The cross flow pumps draw from this second stage and pump through the membrane modules, returning a proportion of concentrated biomass to the primary bioreactor to maintain a balanced biomass.

6. Proving the system

Hamworthy have operated a membrane bioreactor plant at our Poole site for about one year, arranged as a large scale pilot plant treating about 30 tons per day of waste water. The feed is municipal sewage, somewhat weaker in organic strength than vacuum collected sewage, but equivalent to the combined sewage and grey water mix on an average passenger vessel. Comparison with shipboard conditions has shown that significantly higher amounts of paper fibres are present in the ship's system than in the municipal sewage. Additional toilet paper has therefore been added to the trial plant feed obtain representative conditions. Results over 12 week monitored period have been:

	Average	Maximum single value
Suspended solids	7 mg/l	10 mg/l
BOD_5	5 mg/l	7 mg/l
COD	22 mg/l	30 mg/l
Coliform	3 counts / 100 ml	8 counts / 100 ml
Fats, oils, greases		Less than 10 mg/l

The pilot plant is being maintained in operation to test process and auxiliary system options to confirm performance under controlled conditions prior to shipboard use. It has been used to confirm start up procedures, which we have found to be relatively simple. We have also established data for low or zero feed periods, followed by immediate full load operation.

7. Shipboard installation

A nominal 60 ton per day membrane bioreactor has been installed on the Princess Cruises' vessel "Sun Princess", treating black and grey water. This was assembled into the ship over a six week period commencing 4 April 2001, and commenced operation from mid May 2001. Results of testing of the treated water discharged over a ten week period of operation commencing 28 May are:

	Average	Maximum single value
Suspended solids	18 mg/l	32 mg/l
BOD_5	12 mg/l	15 mg/l
COD	113 mg/l	117mg/l
Coliform	4 counts / 100 ml	7 counts / 100 ml

These results are well inside any current regulatory levels, including Alaskan State HB 260. Additionally the results are also inside the levels proposed in the US Federal Bill HR 5666 Section 1404 (the Murkowski proposals).

Completion of IMO and USCG certification testing is expected by the end of September.

During this initial period of operation we have noted a variety of conditions that the system has experienced, well outside those predicted.

Temperature of the influent black water up to 70 degrees centigrade (design allowed for up to 55 degrees centigrade)

Chlorine content of grey water above 5 mg/l for short periods, and at 1.5 mg/l for extended periods (design based on up to 0.5 mg/l)

Fats, oils and greases from galley waste water fed to the grey water collection system

Cellulose fibres from paper in higher concentrations than predicted, with a pronounced tendency to stick together after initial breakdown

The system has handled these conditions well, giving good confidence in the robustness of the process.

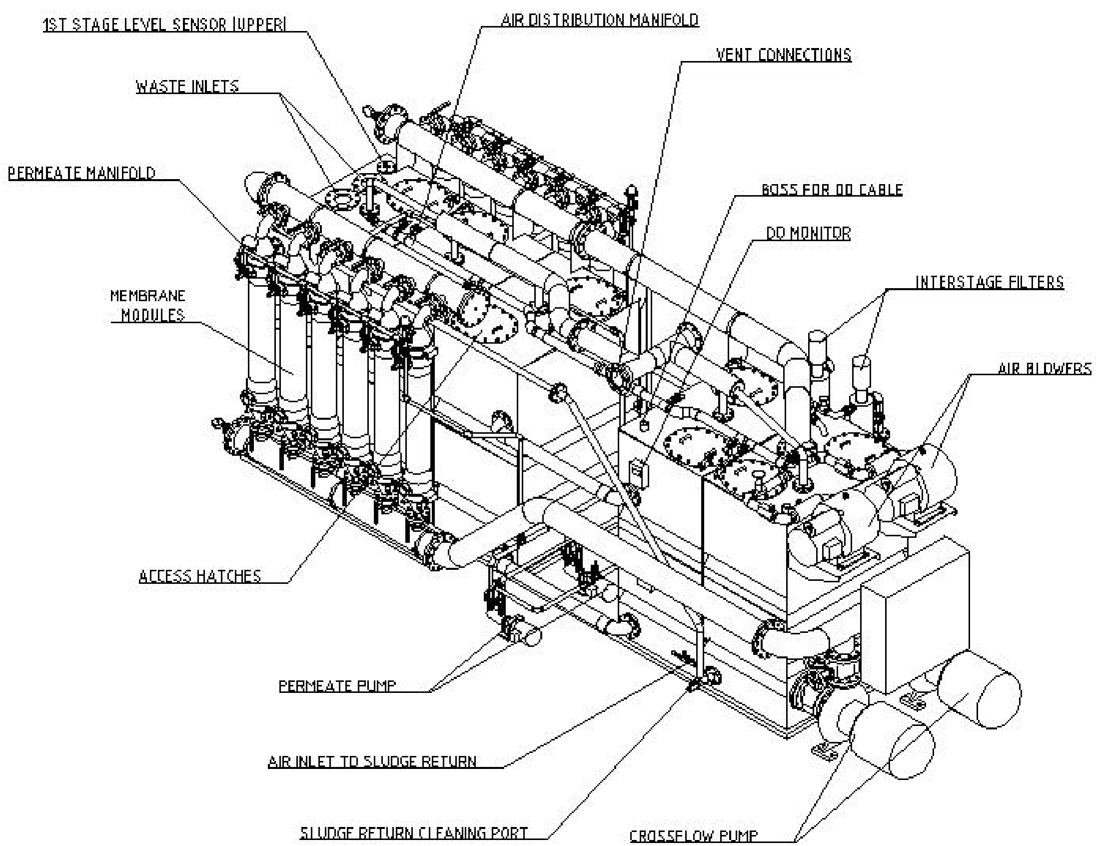
8. Concluding remarks

The system developed has been shown to be capable of treating combined wastewater streams on generated on board ships to the highest effluent quality standards.

It is available as a complete modular package, minimising installation costs when used in new building or major ship conversion / upgrade projects.

It is also particularly well suited to installation into existing vessels by conversion of existing traditional biological treatment units using the extended aeration activated sludge process. Where these original systems were adequately sized for the effective treatment of black water only it is generally possible to convert to a membrane bioreactor capable of treating all black and grey water, with only a small amount of additional space being required for additional system elements.

HamworthyKSE have recognised the special difficulties and challenges in meeting the diverse conversion project requirements. Suitable specialist project management, design and fieldwork teams have been set up to match the particular skills needs of the conversion, new build and upgrade requirements of the marine market.



Membrane bioreactor installed on MV Sun Princess

CURRICULUM VITAE

MARGARET V HEPBURN
MARGARET HEPBURN MARKETING

§ BORN MARCH 1952 in Stoke Upon Trent England

§ At the age of 20 years

Gained a Double Major in PYSCHOLOGY and ENGLISH

From AUCKLAND UNIVERSITY in NEW ZEALAND

§ 1974 SET UP OWN INTERIOR DESIGN COMPANY IN LONDON

very successful 40 employes Designed

for example:	Many private homes and Palaces,
Hotels,	Quinta de la Hotel in Quinta de largo
Company Headquarters	P & O Shipping in Pall Mall
Banks	Arab African Bank
	Arab European Bank

International Stadium in Ryiadh

§ 1986 MOVED TO MONTE CARLO TO RAISE A FAMILY – RETIRED

§ 1998 Family grown up re-entered the market in an area which was and has become an over-riding passion.....THE ENVIRONMENT

SET UP OWN COMPANY IN MONACO WHICH SPECIALISES IN ENVIRONMENTALLY FRIENDLY TECHNOLOGIES

Designed and produced her own range of Biological Cleaning products for the Treatment of organic waste on board ships

HEPBURN BIOLOGICAL CLEANING AND WASTE TREATMENT PRODUCTS
ECONOS STERILSING MACHINE
DEERBERG –SYSTEMS / Hepburn Bio Ship Care
DEERBERG TRADING
RML DESIGN

Abstract

Magaret V. Hepburn
Hepburn Bio Ship Care, MC

"Bio Cleaning and Waste Treatment Products meet the Environmental Challenge"

HEPBURN BIO SHIP CARE PRODUCTS
Offers a complete range of environmentally friendly, BIODEGRADEABLE, BIOLOGICAL cleaning and waste treatment products to pre-treat grey and black water on board ships.

The HBSC philosophy is quite simple. Wherever possible we REPLACE HAZARDOUS CHEMICALS WITH EXCELLENT BIO CLEANING AND WASTE TREATMENT PRODUCTS WHICH NOT ONLY CLEAN DRAMATICALLY BUT ALSO REDUCE BLOCKED DRAINS, BLOCKED GREASE TRAPS,MALODOURS, GREY WATER BACK FLOW AND IMPROVE EFFICIENCY OF SEWAGE STATIONS

These products are designed to 'keep it simple', reducing costs to the operator by dramatically reducing, the number of products needed on board, the risk to personnel and the eco-system of the sea.. For example, Hepburn BIO CLEAN is a colour coded heavy duty cleaner which cleans, walls, floors, tiles, mirrors, windows, baths, basins, toilets, carpets and fabrics, simplifying life for the crew whilst saving money, space, equipment, handling time and most importantly health.
For example, each year a 1200 passenger cruise ship purchases on average 120 TONNES of chemicals and cleaning products per year.
These chemicals kill the natural BIOMASS needed within the waste systems to degrade the organic waste produced on ships, thus allowing the build-up of scale and malodours in the waste pipes, holding and treatment tanks.

ALL these chemicals are ultimately discharged into the Oceans around the world where they deplete the seas of the Oxygen that it needs to survive, (proven by high BOD /COD levels) causing daily destruction of the seas eco-system.

MALFUNCTIONING WASTE EQUIPMENT, HIGH BOD LEVELS MEAN THAT AN ESTIMATED 65 MILLION TONS OF GREY AND BLACK WATER POLLUTE OUR SEAS EVERY YEAR.

These figures are based on 500.000 passenger berths per day, by the year 2004 producing 350 litres of grey water per person per day.

Often these chemicals are, not only difficult to store, hazardous to the crew and equipment on board ship, but damaging to the environment.

Environmental regulations and criminal prosecution have high lighted the need to effectively manage these chemicals throughout the shipping industry…
PREVENTION IS BETTER THAN CURE

Hepburn BIO

meets the

DEERBERG SYSTEMS

ENVIRONMENTAL CHALLENGE

BIOLOGICAL CLEANING AND WASTE TREATMENT PRODUCTS

MARGARET HEPBURN

Hepburn BIO Ship Care

Chairman

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

IS YOUR CREW ADRIFT IN A SEA OF CHEMICALS?

Do you have problems handling and storing hazardous chemicals? Which are:

- **Difficult to control**
- **Damaging to the health of the Crew !**
- **Hazardous to the Environment !**
- **Instrumental in causing blockages/smells!**
- **Steadily increasing costs !**

DEERBERG SYSTEMS

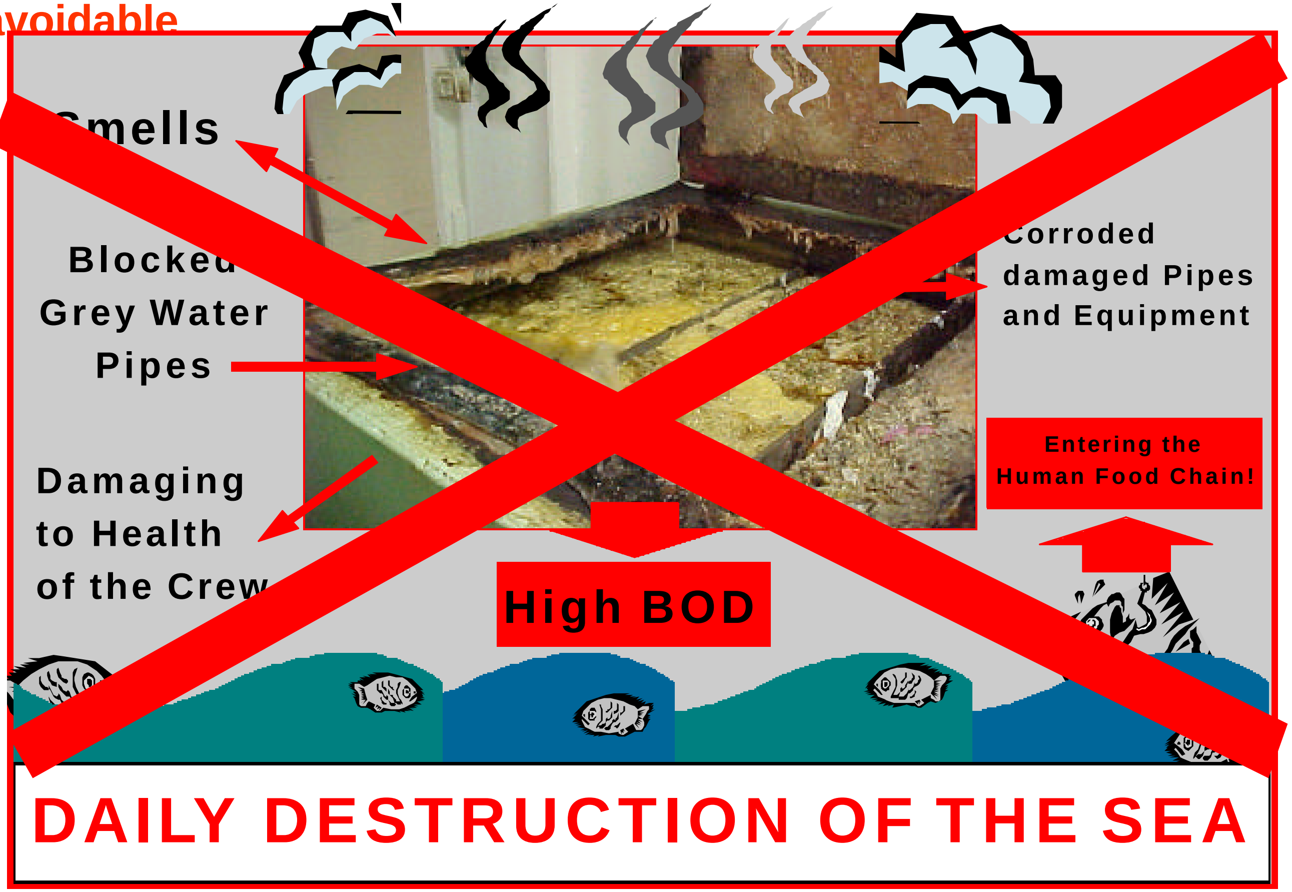
Hepburn Bio

XX meets the

ENVIRONMENTAL CHALLENGE

INDISCRIMINATE USE OF HAZARDOUS CHEMICALS KILLS THE NATURAL BIOMASS

This is avoidable



DEERBERG SYSTEMS

Hepburn Bio

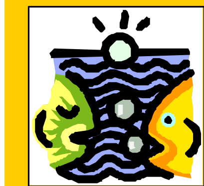
meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO SHIP CARE SOLUTION

Biological Cleaning Products

- ✓ Compatible Products
- ✓ Easy to store
- ✓ Easy to use
- ✓ Reduced costs
- ✓ No Health Risks
- ✓ Safe for the Environment
- ✓ Keep it Simple
- ✓ Reduces BOD & TSS



DEERBERG SYSTEMS

Hepburn Bio

meets the

ENVIRONMENTAL CHALLENGE

HOTEL PRODUCT RANGE

HEPBURN BIO-CLEAN **ONE PRODUCT CLEANS ALL!**

APPLICATIONS

galleys, cabins, public areas, bathrooms, basins, urinals, w.c.'s, baths, tiles, fungi, mirrors, wood work, carpets, fabrics, stainless steel bulkheads,leather

<u>ADVANTAGES</u>

- ✓ **Non hazardous-non corrosive**
- ✓**Builds up a biomass degrading organic waste**
- ✓ **Removes bad odours**
- ✓ **Reduces blockages**
- ✓ **Reduces BOD and Suspended Solids**
- ✓ **Totally harmless to man and the eco-system of the sea**

meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO CLEAN

AREA	USED ON	REPLACES
cabins	carpets mirrors wood	Carpet Cleaner S777-04
	fabrics stains	E840-01
	windows plastic	E863-04
	leather	Leather cleaner
	marble	
Public Areas	all areas as for cabins, toilets	Wine stain remover

DEERBERG SYSTEMS

meets the

ENVIRONMENTAL CHALLENGE

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

HOTEL DEPARTMENT

HEPBURN BIO CLEAN

AREA	USED ON	REPLACES
bathroom	walls	multi purpose cleaner
	floors baths	 glass cleaner Oasis 287
	basins toilets	Oasis 293 toilet cleaner
	taps	Oasis 266
	mirrors	Degreaser HD Cleaner 5A
	tiles grouting fungi	

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO CLEAN

AREA	USED ON	REPLACES
Galley	stainless steel	multi purpose cleaner
	bulkheads floors sinks	floor cleaner Express
pantries		as above
Decks	Outside areas	
	Teak & Tiles	

DEERBERG SYSTEMS

Hepburn Bio

meets the

ENVIRONMENTAL CHALLENGE

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO CLEAN
ADVANTAGES

Compliance	No risk to environment	Non Hazardous
Natural Products	Removes smells	Green Image
Reduces Blockages	MSD work	Happy Passengers
No risk to crew	No headaches	No Skin problems
One Product means	Simplified routine	Happy Crew
Products compatible Non abrasive	Easy to store	No risk to fixtures & fittings
Less product needed	Less gloves	Smells good

ONE PRODUCT CLEANS ALL

DEERBERG SYSTEMS

Hepburn Bio

meets the

ENVIRONMENTAL CHALLENGE

TECHNICAL PRODUCT RANGE

HEPBURN BIO PIPE CLEAN

APPLICATIONS

w.c.'s, urinals, baths, basins

<u>ADVANTAGES</u>

- ✓ **Stops build-up of scale- reduces existing scale**
- ✓ **A biologically friendly product, safe for direct disposal into the environment**
- ✓ **Removes malodours**
- ✓ **Reduces BOD and SS levels**
- ✓ **Safe to handle, easy to store**
- ✓ **No risk to users or equipment, non abrasive**

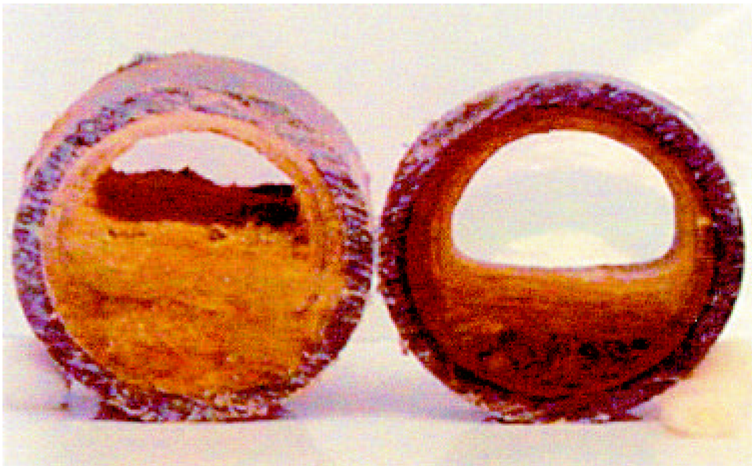
DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

BIOLOGICAL WASTE TREATMENT PRODUCTS

Pipes & Urinals



HEPBURN BIO PIPE CLEAN

ADVANTAGES

- ✓**Restricts and reduces build-up of scale**
- ✓**Removes odours**
- ✓**Reduces SS in tanks**
- ✓**Builds up a bio mass providing an auto cleaning process**

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO PIPE CLEAN

AREA	APPLIED IN	REPLACES
Bathroom	toilet, urinal, bath, basin & shower drains & scuppers	all descalers Microtek, Uriclean, Gamazyne Biotel, Stripallon

ADVANTAGES

DEGRADES HAIR, GREASE AND SCALE IN PIPES

PREVENTS BUILD UP OF SCALE

REMOVES SMELLS

CLEANS GREY WATER TANKS NATURALLY

DEERBERG SYSTEMS

Hepburn Bio

meets the

ENVIRONMENTAL CHALLENGE

BEFORE

AFTER

meets the

ENVIRONMENTAL CHALLENGE

meets the

ENVIRONMENTAL CHALLENGE

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

BIOLOGICAL WASTE TREATMENT PRODUCTS

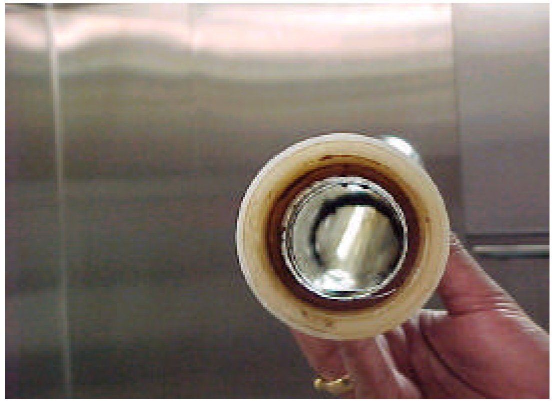
Grease traps

HEPBURN BIO DRAIN PLUS

ADVANTAGES

- ✓ Removes smells
- ✓ No more cleaning out of grease traps
- ✓ Builds up a bio mass resulting in a continuous cleaning action

Sewage Stations



HEPBURN BIO ET

ADVANTAGES

- ✓ Removes odours
- ✓ Improves capacity
- ✓ Reduces TSS level by 60 %
- ✓ Non hazardous
- ✓ Easy to store

DEERBERG SYSTEMS

meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO DRAIN PLUS

For Grease traps

USED ON

Grease traps

REPLACES

Biotel

ADVANTAGES

No more cleaning of grease traps

Savings in man-hours

No more blockages

NO SMELLS

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO ET

USED ON

sewage stations

REPLACES

Biotel

ADVANTAGES

Reduction in SS, TSS, BOD

easier to maintain membranes

Reduced turbidity

easier to clean

savings in man-hours

clear straw colour

Tanks on Oriana were not lowered or pumped in 5 MONTHS offering increased capacity in tanks

NO SMELLS

DEERBERG SYSTEMS

meets the

ENVIRONMENTAL CHALLENGE

HEPBURN BIO DEGREASER

For pulpers, hydrocarbons

USED ON

Pulpers

REPLACES

Oasis

ADVANTAGES

NO MORE SMELLS

REDUCES GREASE

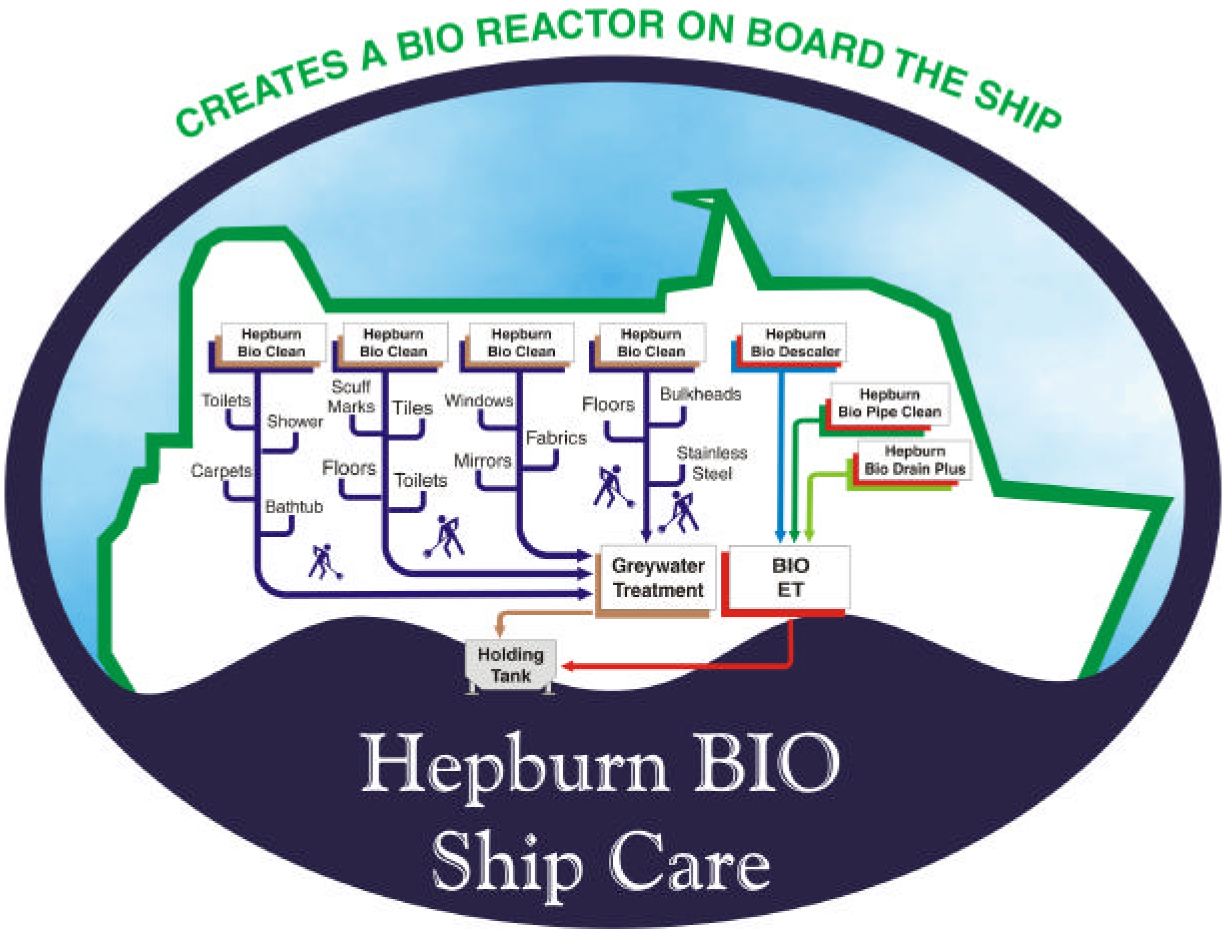
SAVINGS IN MAN-HOURS

DEERBERG SYSTEMS

meets the

ENVIRONMENTAL CHALLENGE

BIOLOGICAL CLEANING AND WASTE TREATMENT PRODUCTS



Oriana

Explorer

Royal Clipper

Star Clipper

Star Flyer

Spirit of Oceanus

Noordam

Wind Spirit

Song of Flower

Seven Seas Navigator

Radisson Diamond

Hepburn Bio

meets the

DEERBERG SYSTEMS

ENVIRONMENTAL CHALLENGE

Interesting thought ...

If you were to ask your regular cleaning supplier to submit a list of advantages which they provide ...... What would they write?????

“We clean quickly, cheaper than most …..

our hidden costs ….. caused by damaging …..your health,

often your fixtures and fittings and certainly the efficiency of your mechanical sanitation devices……………..comes later…..

We don´t do a lot for your environmental image either …..”

CONCLUSION:

PREVENTION IS ALWAYS BETTER AND CHEAPER THAN CURE

DEERBERG SYSTEMS

Hepburn Bio meets the

ENVIRONMENTAL CHALLENGE

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CURRICULUM VITAE

Michael Bryan Spencer, M.S.
Senior Project/Technical Manager
United-Tech, Inc
Tulsa, Oklahoma USA

Bryan Spencer MS is a Senior Project/Technical Manager of United-Tech, Inc. Tulsa, Oklahoma, USA and has over 15 years experience with a broad spectrum of research and development with wildlife, fisheries, and aquaculture fields as well as a myriad of professional experience in all areas of environmental sciences. He has taught various graduate and undergraduate level classes involving environmental impacts and solution development, management planning and technical applications for various areas in the discipline of environmental sciences.

He has focused his vast environmental background and past experience as an inspector with regulatory and environmental affairs agency into managing and developing solutions for municipal, industrial, and maritime waste water treatment and disposal programs through all-natural, cutting edge biotechnology via bioaugmentation and bioremediation processes.

Mr. Spencer in addition to his undergraduate degree of Wildlife and Fisheries Ecology from Oklahoma State University holds a Master's degree in Aquatic/Fisheries Biology from Pittsburg State University.

Abstract

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"Use of All-Natural Microorganisms in Black and Grey Water Systems Onboard Ships"

Black and Grey wastewater discharge from International sailing ships and maritime vessels has become a major worldwide environmental concern. With hundreds of new sailing vessels constructed each year and set sail world round, there is a significant increase in organic waste being discharged from these vessels creating detrimental environmental impacts in the waterways. International and Governmental mandates, permits, and restrictions are aggressively and actively being set to establish criteria and protocol for maritime vessels to follow and provide an environmentally friendly, compliant wastewater in its discharge. Many companies face astronomical fines and penalties for out of compliance discharge levels and cannot incur the significant increase of costs for revamping the vessels to meet the established criteria.

A cost effective, all-natural alternative and environmentally friendly solution to the black and grey wastewater problems onboard vessels is the use of all-natural bacteria and enzymes to achieve reduction and complete degradation of the organic waste before it reaches the point of discharge. All waste stream operations require microbial assimilation of organic waste to produce harmless by-products in the effluent. Pure strain microbes incorporated with purified enzymes can achieve significant reduction and expedite degradation of organic waste in both black and grey water systems with remarkable success. This leads to more efficient waste processing, longevity in processing machinery life, and a cleaner effluent in port and at sea discharges as well as maintaining compliance standards promulgated within the maritime industry.

Optimizing Black and Grey Waste Water Treatment Systems *via* All-Natural Bio-augmentation

Presented by

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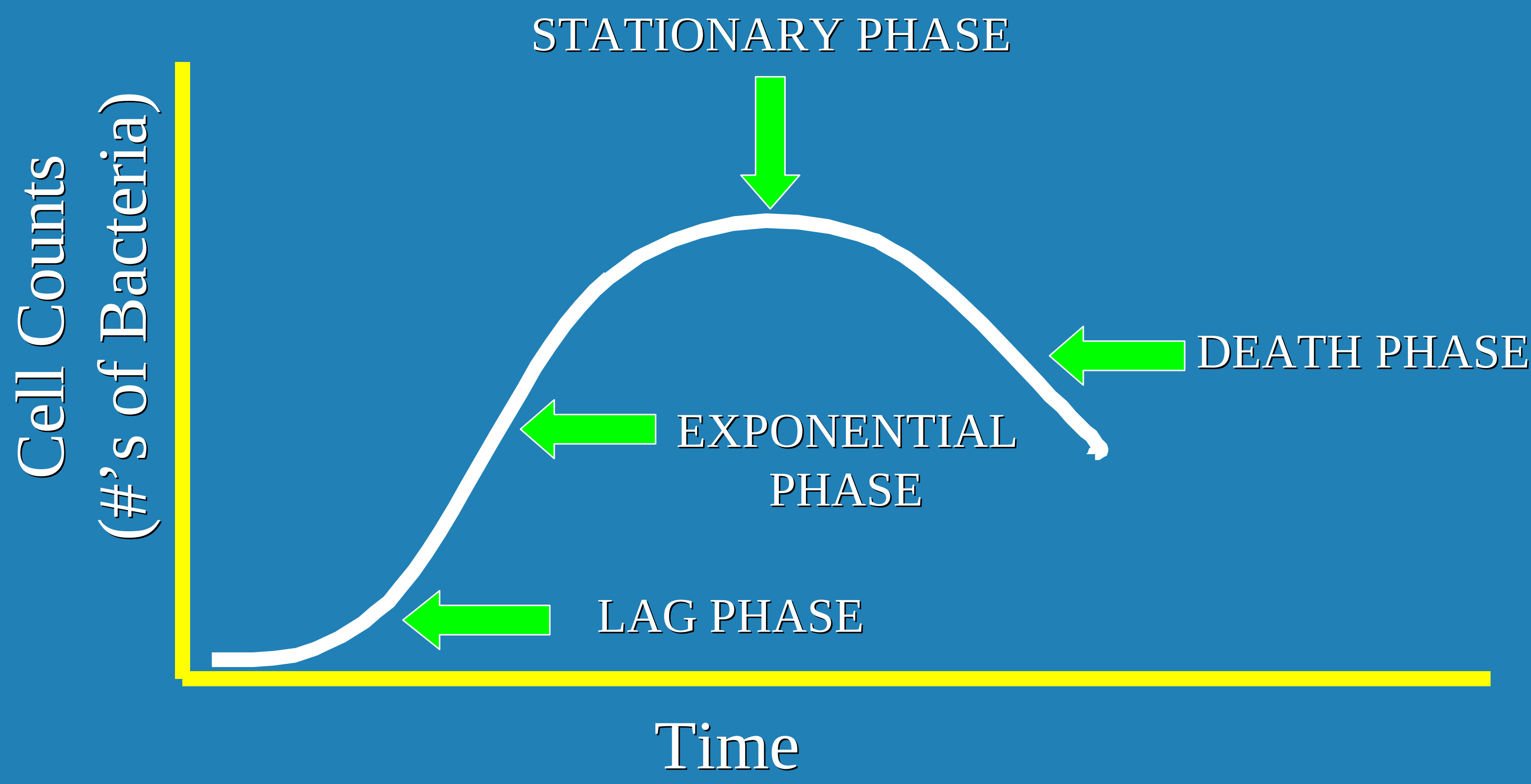
United-Tech, Inc.

- Environmental Biotechnology Firm
- All-Natural Bacteria & Enzyme Products
- FDA-GRAS Listed & AAFCO Named and Defined
- 100% USA Made
- International Experience with Environmental Bio-remediation Programs & Solutions
- Advanced Degreed Technical Staff
- A Comprehensive QA & QC Program Governs Every Product Produced by United-Tech, Inc.

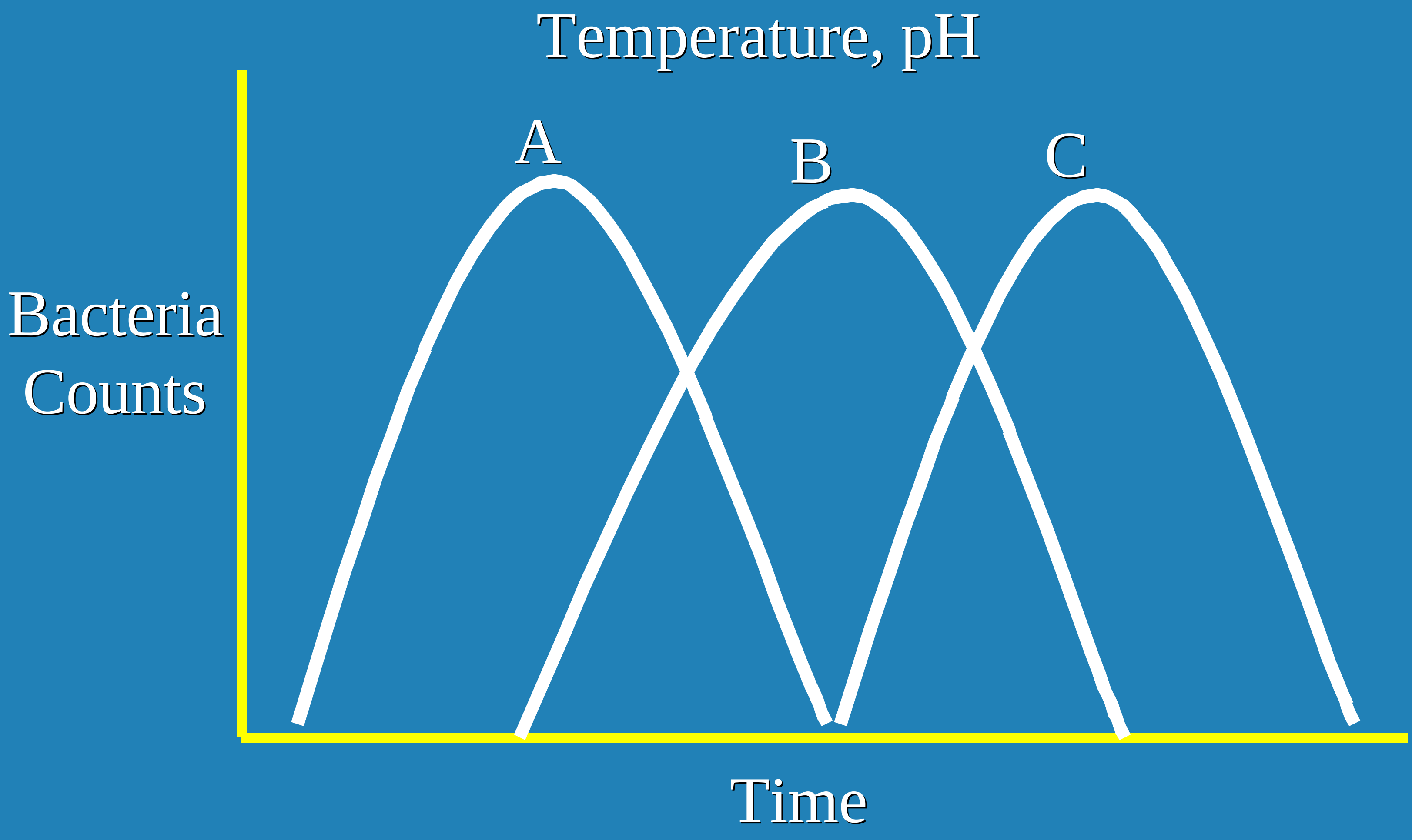
What are Bacteria and their functions in life ?

- Simple singled-celled microorganisms found everywhere on earth & in nature
- At the bottom of the food chain & play a key role in nutrient cycling & bio-magnification processes
- Essential & vital for all functions of life on earth
  - Nutrient Cycling: Agricultural
  - Food Production: Wine, Cheese & Yogurt
  - Biochemical Processes: Digestion
  - Organic Waste Reduction: Wastewater Treatment

Bacterial Growth Curve



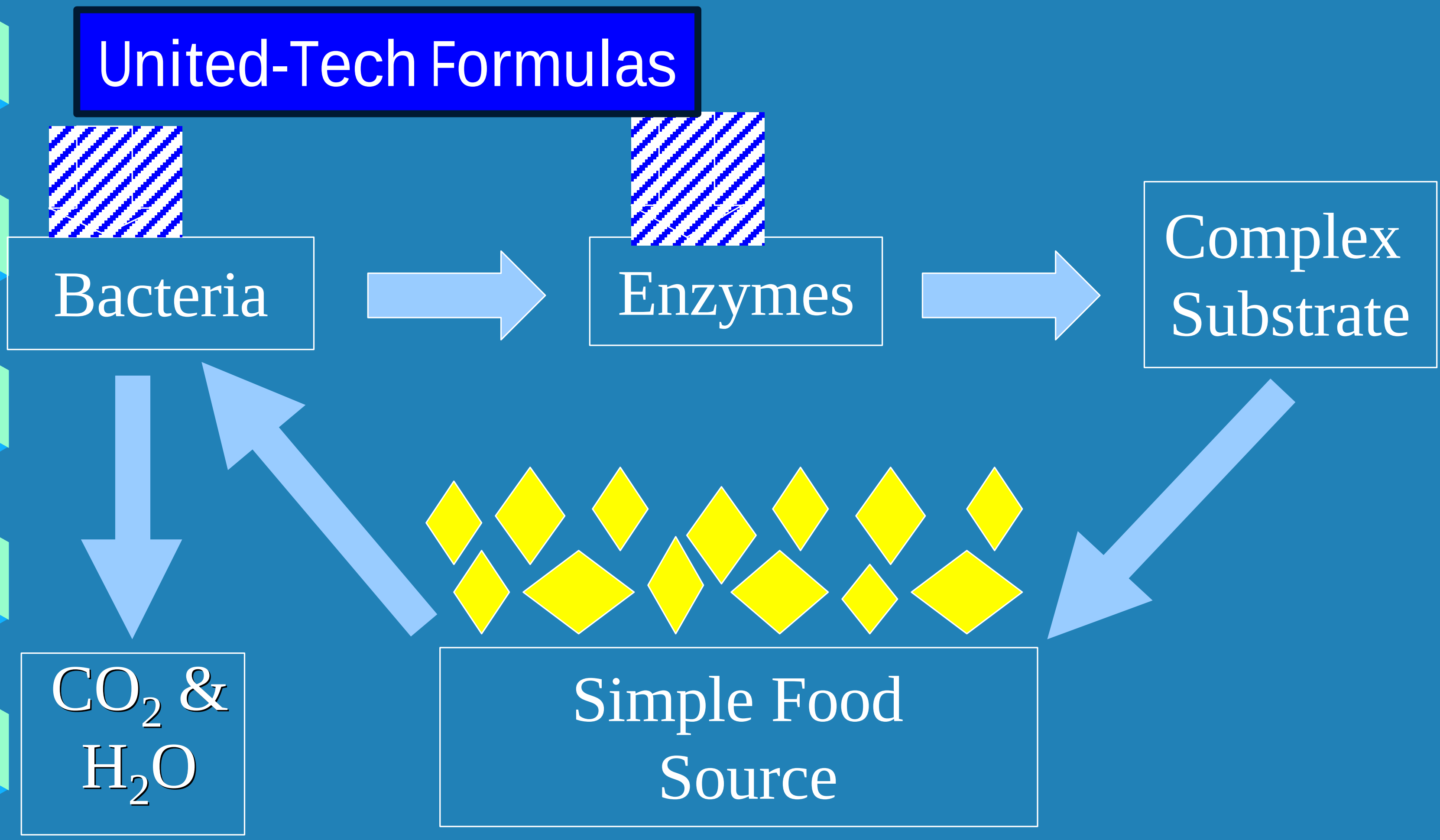
Bacterial (Floral) Succession
(United-Tech Formulas)



What are Enzymes and their functions in life ?

- Natural protein catalysts which accelerate biochemical reactions in nature
  - Highly potent & stable
  - Conserved during reactions & substrate specific
  - Very small concentrations of the proper kinds of enzymes will catalyze millions of reactions
  - All biological organisms naturally produce enzymes or contain symbiotic bacteria that produce them
  - Bacteria produce a matrix of protein catalysts (enzymes) to break down complex substrates into simpler & more readily accessible food sources

Bio-augmentation Utilizing United-Tech Products



Application Parameters

- Dissolved Oxygen (DO): $\geq$ 2.0 ppm
- pH Levels: 6.0 to 9.0 (Optimum 6.6 to 7.4)
- Temperature: 50^0F (10^0C) to 140^0F (60^0C)
- Nitrogen: $\geq$ 5.0 ppm (Optimum $\geq$ 20 ppm)
- Phosphorus: $\geq$ 1.0 ppm (Optimum $\geq$ 5.0 ppm)

Why All-Natural Bio-augmentation ?

- Indigenous micro-flora ?
  - Environmentally sensitive & operate across a short-range spectrum of environmental parameters
  - Mother Nature seldom provides the right blend of bacteria & enzymes "*in high enough concentrations* " to completely biodegrade high concentrations of human & animal generated waste
- United-Tech Formulas enhances nature 's natural breakdown process by providing high concentrations of the right blend of bacteria & enzyme specific for organic waste reduction

Benefits of All-Natural Biological Treatment Programs

- Complete Biodegradation & Elimination of Organic Waste
- Non-chemical / Non-toxic / Non-corrosive
- Safe for All Types of Applications
  - Will Not Harm Plants, Animals, Fish or Humans
  - Reduces & Eliminates Current Waste Problems, while Combating & Preventing the Accumulation of New Organic Waste
  - Reduces & Eliminates Obnoxious Odors
  - Restores Free Flowing Drains & Improves Operating Efficiency in Waste Processing Components

Problematic Biological Products

- Bacteria Only Products
  - Require lag time to develop & reproduce
  - Very slow activity & development
  - Operate under optimum conditions only
- Enzyme Only Products
  - Break Apart & Emulsify Only *vs.* Complete Breakdown
  - Transforms & moves waste down stream resulting in problems with increased loading to WWTP's
- Increasing Restrictions & Regulations On Use with these types of products

Primary United-Tech Products Utilized in the Maritime Industry

- **BZT® Waste Digester**
  - Galley Floors / Drain lines / Toilets & Urinals
  - Marine Sanitation Devices (MSD's)
  - Grease Traps / Grey Water Filters
  - Black / Grey Water Holding Tanks
- **BZT® Xtra-Wet**
  - Galley Floors / Stainless Steel Equipment / Food-Prep Areas / Machinery & Mechanical Equipment
- **OBT™ Oil Degradation Treatment**
  - Oily Water Bilges & Separators / Holding Tanks / Open Water Spills / Fuel Oil Spills

Shipboard Problematic Areas Targeted for Organic Waste Reduction *via* All-Natural Bio-augmentation

- Drain lines: Sinks / Showers / Toilets / Floor
  - Produce Bad Odors from Non-Beneficial Bacteria
  - Frequent Blockages resulting in Frequent Plumber Calls & Intense Modifications with the Waste Stream
- Galley Floors , Pulper Units & High Use Floor Drains
  - Produce Bad Odors
  - High Volume of Waste Produced and Disposed of Daily
- Food-Prep Areas / Stainless Steel Equipment
  - Unsanitary with High Grease Build Up Conditions
  - Regulated Protocol for Cleaning Procedures

Shipboard Problematic Areas Targeted for Organic Waste Reduction *via* All-Natural Bio-augmentation

- Marine Sanitation Devices (MSD's)
  - High BOD_5 / COD / TSS / Fats, Oils, Greases
  - Mandated on Effluent Quality in Discharges in Port & at Sea
  - Heavy Organic Loading creates Inefficient & Uneven MSD Operation
- Grease Traps & Grey Water Filters
  - High TSS, Fats, Oils, Greases & Inorganic Material
  - Receive Heavy Organic Loading & Flow on Daily Basis
  - Extreme Fluctuations in pH Levels

Shipboard Problematic Areas Targeted for Organic Waste Reduction *via* All-Natural Bio-augmentation

- Black & Grey Water Holding Tanks
  - Mandated on Effluent Quality in Discharges in Port & at Sea
  - Heavy Accumulation of both Processed & Unprocessed Organic Waste
- Oily Water Bilges & Separators
  - Total Petroleum Hydrocarbons (TPH's) / Gasoline Range Organics (GRO) & Diesel Range Organics (DRO)
  - Fuel Oil / Waste Oil / Various Other Regulated Contaminants
  - BTEX: (Benzene - Toluene - Ethylbenzene - Xylene)

International Maritime Regulations
MARPOL (1973 to date)

- **MARPOL - International Convention for the Prevention of Pollution from Ships at Sea**
  - Annexed based on pollution problems they address
    - Annex I - Oil
    - Annex II - Hazardous Liquid Substances (carried in bulk)
    - Annex III - Hazardous Substances (carried in packaged form)
    - Annex IV - Sewage
    - Annex V - Plastics
    - Annex VI - Air Pollution (Actively Pending)

Future in Maritime Regulations

- CMC: Center for Marine Conservation
- Pilot program to develop *Zero Discharge* program
  - Requires vessels to store generated waste until it can be properly disposed of in port facilities
  - Most vessels and ships do not have the capability to store generated waste for long period nautical trips
- Longer holding time of shipboard generated waste will make the microbial degradation process even more important in full scale bio-remediation of the vessel's waste streams

Future in Maritime Regulations

- Guidelines & More Stringent Restrictions on the use of Chlorine & Chlorides for Disinfecting Purposes & Compliant Discharges at Sea & In Port
- Identifying and Controlling Non-point Sources of Pollution on all types of Ships & Commercial Vessels
- Phasing Out the use of Environmentally Harmful Chemicals / Acids / Detergents

Future in Maritime Regulations

- The push is on to develop *"Green Chemistry"* processes & products that not only minimize environmental and health risks, but also promote *"Technology for a Sustainable Environment"* by incorporating renewable resources & biological processes
- *"Green Chemistry"* is the design, manufacture & use of environmentally benign chemical products & processes that prevent pollution & reduce environmental & human health risks

UNITED - TECH, INC.
“The Natural Alternative”

Sometimes Big Problems

Require

Microbe Solutions

“ All - Natural Biotechnology “

“ When you have “ Sound Applied Biological Science” behind the creation of all-natural formulas, you truly then have “ Sound Applied Biotechnology “ which compliments Mother Nature in a perfect harmonious balancing of life “

Michael Bryan Spencer

2001

CURRICULUM VITAE

John H. Klie, M.Sc.
General Manager, Marine & Defence Systems Division
ZENON Environmental Inc.

John H. Klie is the General Manager, Marine & Defence Systems Division for ZENON Environmental Inc. In this role, John is responsible for the operations of the division, overseeing all aspects of sales and marketing, business development, customer relations, program management, and contract negotiations.

During his time with ZENON, John has been involved the provision of shipboard water and wastewater treatment equipment including ZENON's Shipboard Membrane Bioreactor system currently operating on several Holland America Lines vessels. John has also served as the Chairman of the NATO Industrial Advisory Group (NIAG) on the "Environmentally Sound Ship of the 21st Century," and has been intimately involved with all ZENON naval projects including the Aerated Membrane Treatment Systems (AMTS) for the U.S. Navy and ZENON's Shipboard Reverse Osmosis Desalination (SROD) system which is in-service on every Canadian Naval operational vessel.

Prior to joining ZENON, John has worked in the industrial water treatment and aerospace industry in various sales, marketing and program management capacities. John began his career in the Canadian Military as an Infantry Officer with service across Canada, Europe and in the National Defence Headquarters in Ottawa.

A 1984 graduate of Royal Military College of Science (RMCS – Shrivenham), John completed the Division 1 Army Staff Course in military science and technology. Prior to attending RMCS he obtained his Masters of Science degree in Chemistry, in 1980, and a Bachelor of Science (Honors Chemistry and Mathematics) in 1978 from the University of Waterloo in Canada.

Abstract

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Seattle, WA, USA

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Evac Vacuum Systems
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"RETROFITTING SHIPBOARD GREY & BLACKWATER TREATMENT SYSTEMS USING IMMERSED MEMBRANE BIOREACTOR TECHNOLOGY"

After many years experience of applying ZeeWeed® ZenoGem® immersed membrane bioreactor technologies to land-based industrial and municipal wastewater treatment, ZENON Environmental Inc. has successfully developed its unique and patented marine ZenoGem® technology for naval and cruise ship black and gray water treatment. The system can be adapted either by retrofitting onto the existing ships or configuring for new build design.

This paper discusses the concepts and the techniques developed for retrofitting this technology to existing cruise ships. Two systems that have been installed on cruise ships are used as examples to illustrate how this proven marine ZenoGem® technology is retrofitted. The system operation performances are summarized to demonstrate that the ZenoGem® effluent quality far exceeds the requirements of all the exiting environmental regulations, including Miami Dade County Code, IMO and US Coast Guard, as well as the water discharge standard incorporated in HB260 by the Alaska State Legislature.

Waste management is also discussed, with focus on options and challenges of sludge handling and post-treatment for shipboard applications.

RETROFITTING SHIPBOARD GREY & BLACK WATER TREATMENT SYSTEMS USING IMMERSED MEMBRANE BIOREACTOR TECHNOLOGY*

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*Presented at the Maritime Environment International Conference and Exhibition "Ballast Water, Waste Water and Sewage Treatment on Ships and in Port", 12th – 14th September 2001 Bremerhaven, Germany

ABSTRACT

With more than ten years of experience applying ZeeWeed® ZenoGem® immersed membrane bioreactor technologies to land-based industrial and municipal wastewater treatment, ZENON Environmental Inc. has successfully developed its unique and patented marine ZenoGem® technology for naval and cruise ship black and gray water treatment. The system can be adapted either for retrofitting existing ships or configuring for new build design.

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INTRODUCTION

Cruise ships typically rely on collection-holding-transfer (CHT) techniques to handle gray water generated onboard. Gray water is stored while navigating in restricted waters and discharged overboard while outside the restricted water boundaries. Gray water storage capacity generally is limited to less than two days, depending upon the passenger load and ship design. This is particularly challenging for cruise ships that make lengthy itineraries within restricted water boundaries, such as the Alaskan Inside Passage.

Black water is vacuum-collected in most cases and treated in two different approaches: 1) conventional biological sewage plants, or 2) physical/chemical techniques. These conventional technologies are being challenged to meet today's stringent requirements for wastewater discharge.

Over the last number of years, marine pollution from cruise ship operations has drawn more and more public attention. This has resulted in an increasing number of rules and regulations being established by international, national and local legislators, besides the well-known IMO rules. For example, Alaska State Legislature recently passed the Bill HB 260 that prohibits commercial passenger vessels from discharging untreated gray and black water into its marine waters. The provincial Legislature of British Colombia of Canada is under public pressure to establish a similar regulation to protect Canadian marine waters. Additionally, the Canadian Coast Guard has been reviewing its own marine regulations. These regulations are summarized in Table 1.

Table 1: Current Marine Regulations

Parameters		IMO	US Coast Guard	Miami Dade Code	US Navy	Alaska Standard	Title 22 California *	Canadian Coast Guard **
BOD5	Mg/L	50	50	30	50			20
TSS	Mg/L	50	150	40	100	150		20
Fecal Coliform	MPN/100ml	200	200	0	200	200		20
Total Coliform	MPN/100ml			1000			2.2	

* Disinfected tertiary recycled water defined in Section 60301.230, Title 22 Code of California Regulation.
** Non - official

Therefore, environmentally sound and legally compliant operation becomes a priority of cruise ship operators and innovative technologies are expected to be able to treat gray and black water prior to discharge within a limited footprint. The International Council of Cruise Lines (ICCL) recently announced that its members have unanimously adopted mandatory environmental standards for all of their cruise ships and compliance with these standards is a condition of membership in the ICCL. These standards are based on principles that include designing and constructing cruise ships to be as environmentally friendly as possible, embracing new technology, and complying fully with international and U.S. environmental laws.

Realizing this growing environmental concern, Holland America Line Westours (HALW), a pioneer in onboard wastewater treatment, started proactively two years ago applying the ZenoGem® membrane bioreactor systems to treat black and gray water on its vessels operating in Alaska. HALW and other cruise ship operators expect to recycle or reuse the treated wastewater for toilet flushing, fire fighting and laundry use. Such applications require higher quality of treated wastewater and regulations have already been established, in some cases, to regulate these quality requirements. For example, California State Department of Health Services has set up regulations for recycled wastewater quality standards for particular applications, as defined in Title 22 Code of California Regulation.

Increasingly stringent regulations provide not only challenges but also opportunities for suppliers and manufacturers of wastewater treatment equipment to develop their systems to suit shipboard applications. Of all the physical, chemical and biological technologies that are commercially available today, membrane bio-reactors (MBR) have been proven the most suitable and reliable technology to treat shipboard black and gray water because of the MBR's compactness, simplicity and effectiveness in removal of total coliform, fecal coliform, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS).

ZeeWeed® ZenoGem® technology is an immersed membrane bioreactor originally developed for industrial and municipal wastewater treatment. After ten years of experience with land-based wastewater treatment, ZENON successfully developed its patented marine version of ZenoGem® for black and gray water treatment on board naval and cruise ships. Compared to other membrane bioreactor configurations, ZeeWeed® ZenoGem® technology offers the unique advantage of being easily and cost effectively retrofitted onto these vessels.

This paper focuses on how to retrofit ZenoGem® technology onto existing cruise ships, illustrated by three retrofitted examples.

ZEEWEED® ZENOGEM® TECHNOLOGY

The ZenoGem® process is a proprietary ZENON technology that consists of a bioreactor integrated with ZeeWeed® ultrafiltration membranes. The membrane system replaces the secondary clarifiers and sand filters in conventional activated sludge treatment. Figure 1 presents the process flow diagram of an immersed membrane bioreactor with the membranes directly inserted in the biomass. A typical system will have the following major components: membranes, fine screen, permeate pumps, bioreactor, blowers for process, as well as membrane scouring and clean-in-place equipment for membrane backpulsing / washing.

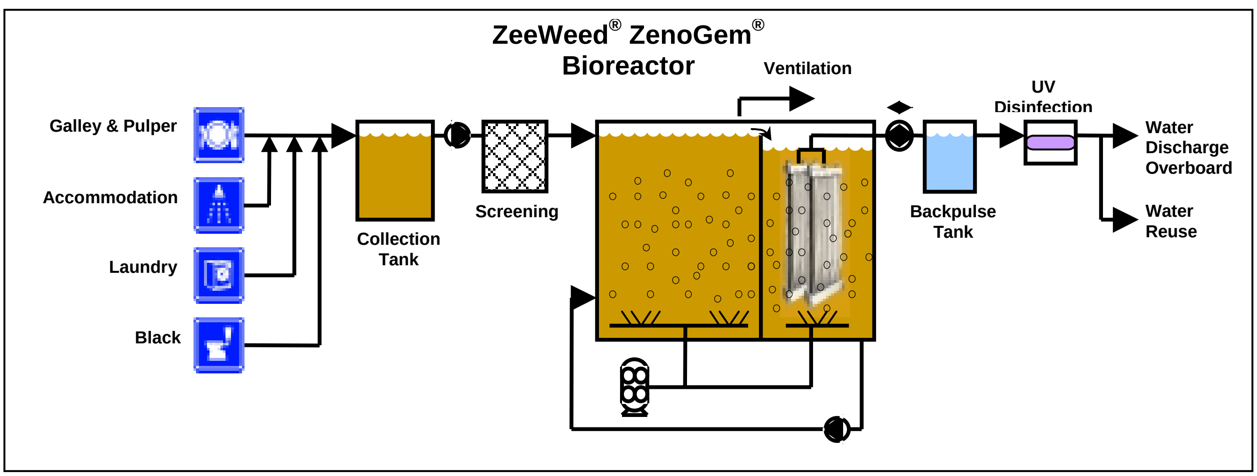

Figure 1. Typical process flow diagram of a ZenoGem® membrane bioreactor

In a conventional biological system, performance and efficiency is limited by the ability of the clarifier to settle the solids from the mixed liquor stream. This is a function of operator skill, sludge settleability, basic clarifier design, solids management, and the extent and rate of variability in hydraulic or organic loading. When upsets occur, solids can be lost and plant performance compromised. Therefore, in order to maintain adequate settling characteristics, suspended growth activated sludge plants are limited to mixed liquor suspended solids (MLSS) concentrations of less than 3,500 mg/L. In contrast, the MBR process eliminates the need for the normal clarification process, utilizing the membrane as a simple, reliable and positive barrier to all suspended solids and microorganisms. Separation performance is independent of the quality, or condition of the biological process fluid and the entire treatment process is simplified. Since sludge settling is not required, membrane bioreactors are designed with mixed liquor suspended solids of 8,000 to 15,000 mg/L. This means that any conventional plant capacity can be increased by as much as 4 times just by replacing the clarifier with membranes and increasing the plant's MLSS.

The elevated MLSS concentration enables the system to reduce the bioreactor volume, achieve high levels of BOD removal, handle high concentration spikes, survive episodes of toxic material introduction and minimize the sludge wasting. Furthermore, process upset problems associated with sludge bulking and difficult mixed liquor floc conditions are eliminated. As a result, a very stable and efficient biological process is maintained.

ZW500a Module ZW500c Module ZW500c Cassette

Figure 2. ZeeWeed® 500 Series

ZeeWeed® are proprietary hollow-fiber ultrafiltration membranes that are immersed within the bioreactor, in direct contact with the mixed liquor. The ZeeWeed® hollow fibers are contained in bundles called modules, which are assembled into cassettes. Through the use of a centrifugal pump, a vacuum varying between 2 and 9 psi is applied to a header connecting the membrane modules. The vacuum draws the treated water through the hollow fiber membranes and all particulate matter and the mixed liquor solids are rejected at the surface of the membranes. With a pore size of 0.04

μm, the ZeeWeed® membrane is a complete, physical barrier to anything larger, including bacteria, most viruses and other suspended solids.

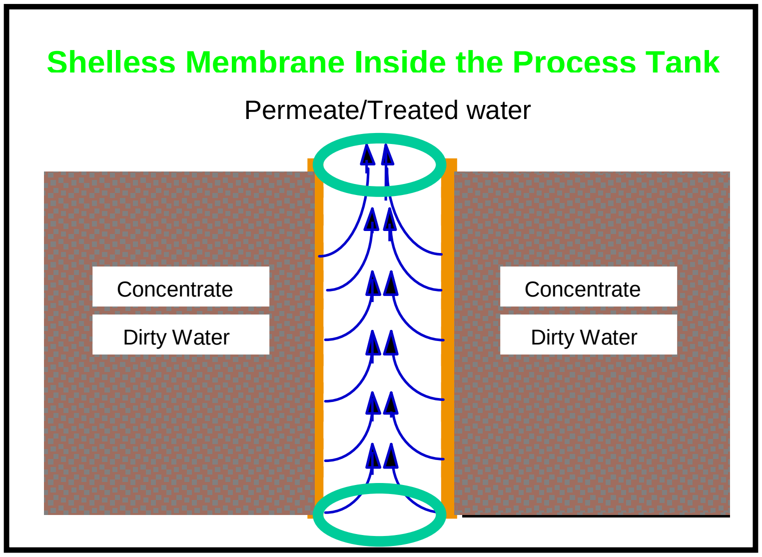

Figure 3. Outside In Process

The ZeeWeed® membranes are automatically backpulsed on a regular basis using collected permeate. A coarse bubble air diffuser is located at the base of each membrane module. The airflow provided by the diffuser scours the external surface of the membrane transferring the rejected solids away from the membrane surface. This airflow also provides a portion of the biological oxygen requirements. Supplemental coarse or fine bubble diffuser grids may be used to supply the remainder of the biological oxygen requirements. Sludge is wasted directly from the aeration tank at the operating MLSS concentration between 8,000 – 15,000 mg/l. (Mourato et al., 1996).

ZENOGEM® SHIPBOARD APPLICATIONS

Applying ZenoGem® to shipboard gray and black water treatment is essentially the same as applying it to land-based municipal sewage treatment. However, there are significant design conditions, which result in a difference between the land-based and the shipboard systems. These include:

- Higher organic strength and solid content in shipboard wastewater streams require a larger bioreactor while limited space availability results in a contradictory condition. This contradiction induces, to the bioreactor, a high BOD loading or F/M ratio, a short hydraulic retention time (HRT) and a short sludge retention time (SRT).

- Limited tank volume and limited liquid depth provide challenges for efficient oxygen transfer to meet high oxygen demand. A low oxygen transfer rate (OTR) may be encountered under the requirement for a high oxygen uptake rate (OUR). Limited ventilation conditions also restrict the airflow rate to the bioreactors for oxygen supply.

- High influent temperature, high ambient temperature and high organic loading may bring the bioreactor temperature over the mesophilic range, inducing process instability as well as foaming potential. Some manufacturers include heat exchangers in the MBR systems to cool down the bioreactors because the energy consumption of high-pressure/flow re-circulation pumps in the system adds significant heat energy to the waste stream.

- High ambient temperature, humidity and moving/vibrating platform require certain mechanical considerations. Therefore, some analytical techniques and instruments commonly used in land-based systems may not be suitable to shipboard systems.

- Simplicity of the system is crucial for operation and maintenance since the ship's crew may already be heavily loaded with operational tasks. Additionally, the crew usually has no personnel experienced in operation of a conventional MBR system.

ZeeWeed® ZenoGem® systems are able to overcome, or tolerate, these severe conditions, and thus are very attractive for shipboard application because of its compact footprint, flexibility of adapting into the ship's configuration, and simplicity of operation and maintenance. Since ZeeWeed® membranes are immersed into the bioreactor as opposed to being skid-mounted on the deck, space requirement is significantly minimized and equipment requiring machinery room space is limited to process blowers, pumps, MCC and control panels.

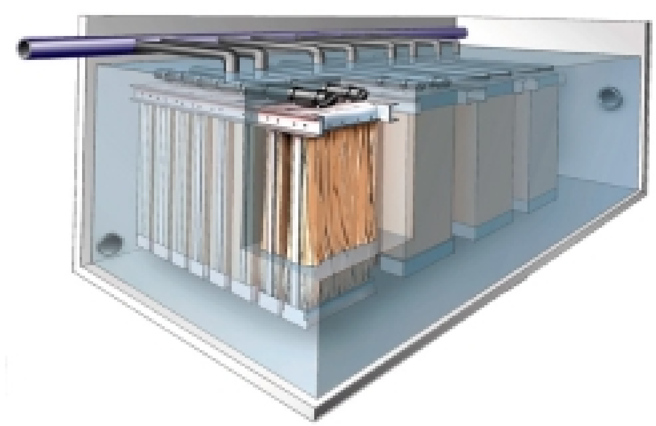

Figure 4. ZeeWeed® Immersed Membrane Bioreactor

Moreover, ZeeWeed® ZenoGem® systems are very energy efficient, compared to other MBR configurations, because ZeeWeed® membranes are operating under very low transmembrane pressures. Although energy consumption rates do not initially seem to be a factor, energy efficiency that ZeeWeed® ZenoGem® systems enjoy is significantly beneficial in reducing the bioreactor temperature so that heat exchangers are not necessary for year-round operation. For example, HALW ms Statendam and Zaandam systems have already demonstrated ZenoGem® operation without heat exchangers.

RETROFITTING CONCEPTS

Retrofitting ZenoGem® systems onto an operating cruise ship is entirely case-dependent. There are numerous factors, which can have a significant impact on the system design and configurations. These include gray water storage capacity, existing pre-treatment of black and gray water, tanks to be used as bio-reactors, space availability, effluent quality requirements, sludge handling and operational philosophy (redundancy, down time and tank inspection frequency, etc.)

However, the most critical is to identify bioreactor tanks that are able to provide sufficient volumes for the biological process and sufficient liquid depth for oxygen transfer. Of the retrofitting approaches ZENON has investigated, the following options are considered the most feasible and realistic:

- To convert existing tanks to bioreactors, such as potable water tanks.
- To replace existing sewage treatment plants.
- To replace existing black water physical chemical (dilution/disinfection) systems.
- To use double bottom gray water collection tanks.
- To construct new tanks.

Each of these options has its specific advantages and disadvantages. Selection of retrofitting approach requires comprehensive evaluation of particular ship conditions.

Option 1: Converting Potable Water Tanks

Existing potable water tanks are favored for use as ZenoGem® bioreactors. These tanks are originally designed to store potable water for daily consumption onboard and are often oversized. In some cases, all available tanks are not used, as some of these potable water tanks are not required during normal ship day-to-day operations.

These tanks are typically large in volume and tall, with an approximate overall height of 4-5 m and have few internal structures. These tanks can be easily converted into bioreactors simply by adding an aeration grid and ZeeWeed® membranes to create an ideal ZenoGem® bioreactor system.

Converting the potable water tanks into bioreactors offers the advantages of saving space and capital cost. ZENON's systems will be installed while the ship is underway with no interruptions to daily operation.

Holland America Line Westour's ms Zaandam and ms Volendam have been retrofitted with ZenoGem® systems utilizing this approach.

Option 2: Replacing Sewage Treatment Plants

Most cruise ships have several (3-4) conventional biological sewage treatment plants onboard to treat vacuum-collected black water. These plants operate on a conventional biological process of activated sludge bio-oxidation, gravity clarifying and chlorine disinfection. Because of high BOD_5

and ammonia concentrations in the vacuum-collected black water, these plants require water-dilution, using tech water, gray water or seawater to minimize potential toxicity to the microorganisms. The dilution ratio ranges from 200% up to 1500%, depending upon toilet flushing water consumption rate and the sewage treatment plant design.

As a consequence, a large bioreactor tank is employed to provide sufficient volume for a reasonable hydraulic retention time (HRT) for the diluted black water. The process tank also includes a clarifier for solid-liquid separation. These systems typically operate at a low mixed liquor suspended solids (MLSS) concentration of <3500 mg/L. A high Food/Microorganism (F/M) ratio and a short sludge retention time (SRT) can make these plants sensitive to influent quality and dilution control, becoming unreliable and unable to consistently meet the effluent discharge standards.

If the bioreactor and clarifier are combined into one tank and ZeeWeed® membranes are inserted, the plant becomes a ZenoGem® system. The space occupied by a conventional sewage treatment plant can hold a ZenoGem® system with much higher treatment capacity. Typically, if all the existing black water sewage treatment plants onboard a ship are converted into ZenoGem® systems, they would be able to treat the combined volume of all black and gray water generated on the ship.

Multiple systems onboard a ship provides flexibility and redundancy for the management of black and gray water. However, this advantage must be weighed against the disadvantage of additional capital cost. Therefore, it option should only be considered if there are no existing tanks available for use as a bioreactor.

Option 3: Replace Black water Physical Chemical Systems

Some cruise ships are equipped with physical chemical treatment systems which function using a holding-dilution-disinfection technique to handle black water generated onboard. The systems usually include vacuum collection units, holding tanks, seawater dilution, hypochlorite injection and treatment units. These treatment units use a combination of dilution, mixing/maceration and disinfection to treat shipboard wastewater; however, the effluent often contains a high amount of chlorine, which is a growing environmental concern.

These treatment units can be replaced with a ZenoGem® system by converting their tanks and other ship tanks depending on the vessel configuration.

Option 4: Using Double Bottom Tanks

Double bottom tanks are often used for gray water collection or ballast water storage. These double bottom tanks are large in volume but short in height (<1.8 m) and have significant internal structures. These structures prohibit the flow of water making it difficult to generate effective mixing and oxygen transfer to feed the bioreactor. There is also a possibility of corrosion from anaerobic sludge collecting in corners.

However, these tanks can be considered given there are limited alternatives such as space constraints, or lack of other tanks available for use as bioreactors. In this case, tank corrosion prevention must be adequately controlled. Because the double bottom tanks are short in height, separate ZeeWeed® tanks are necessary and novel oxygen transfer approaches need to be considered.

Despite its limitations, this concept has been successfully adopted by Holland America Line Westour ms Statendam, which has been retrofitted using this approach.

Option 5: Constructing New Tanks

Constructing new bioreactor tanks appears the easiest option if space is available. However, the challenge is to find such space for new tanks on an already densely configured cruise ship. In these cases, the most suitable space may be in the storage area. As the shape of the tank is not critical for operating a bioreactor, it can be built directly onto the ships hull or frames in a non-uniform shape.

CASE STUDY

Over the last 18 months, ZENON Environmental Inc. has been working with Holland America Line Westours (HALW) to retrofit ZeeWeed® ZenoGem® systems onto their cruise vessels operating in Alaska. This follows the successful testing of ZENON's pier-side demonstration system for shipboard black and gray water treatment by the US Navy, Naval Surface Warfare Center, Carderock Division. This demonstration system was designed to treat combined raw black and gray water discharged directly from naval ships under extreme conditions. The demonstration successfully concluded that under all testing conditions, the ZeeWeed® ZenoGem® system met all effluent discharge standards set by the US Navy.

Case 1: ms Statendam System

HALW ms Statendam was selected as the first vessel to be retrofitted with a ZenoGem® system. Though the existing sewage treatment plants treat black water, effluent from these plants do not meet current discharge standards and therefore is directed to the ZenoGem® system for further treatment. Due to limited tank capacity, two double bottom tanks were chosen as bioreactors with two small ZeeWeed® membrane tanks built and placed on top of the double bottom tanks. All gray water, including galley water (and "Somat" effluent), laundry water, and accommodation water, is transferred to the bioreactor from gray water collection tanks while black water enters the bioreactor through the existing sewage treatment plants. This reduces the BOD/TSS of black water, which minimizes piping modifications. Figure 5 shows the simplified process flow diagram of the ms Statendam system.

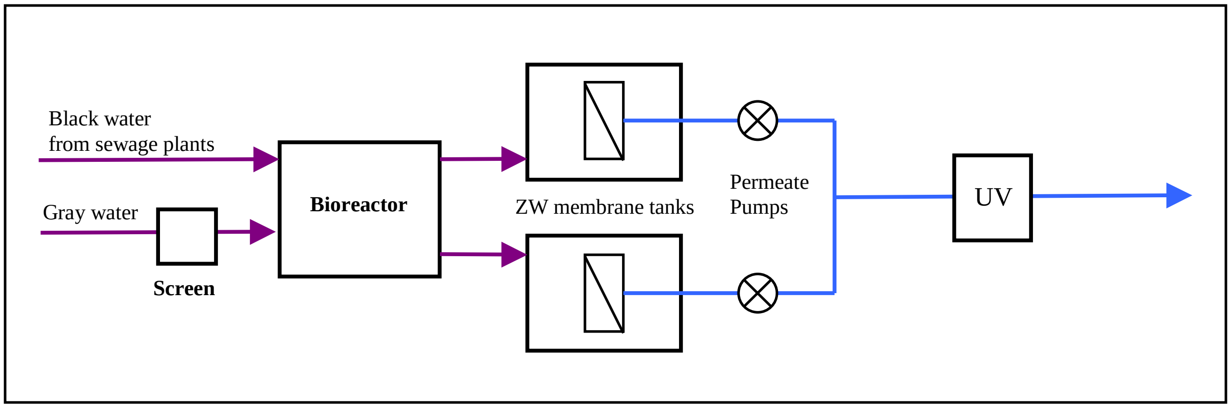

Figure 5: Conceptual Process Flow Diagram of ms Statendam System

Oxygen generation and dissolution systems are included to provide sufficient dissolved oxygen in the double bottom tanks. Two ZeeWeed® membrane tanks are used to offer flexibility and continued operation during membrane cleaning, i.e., permeate production on one ZeeWeed® train can be increased to temporarily compensate for the other while it is shut down for cleaning and/or maintenance. The entire system consists of only six pumps, two blowers, two sets of oxygen generators, dissolution systems, and a UV disinfection unit.

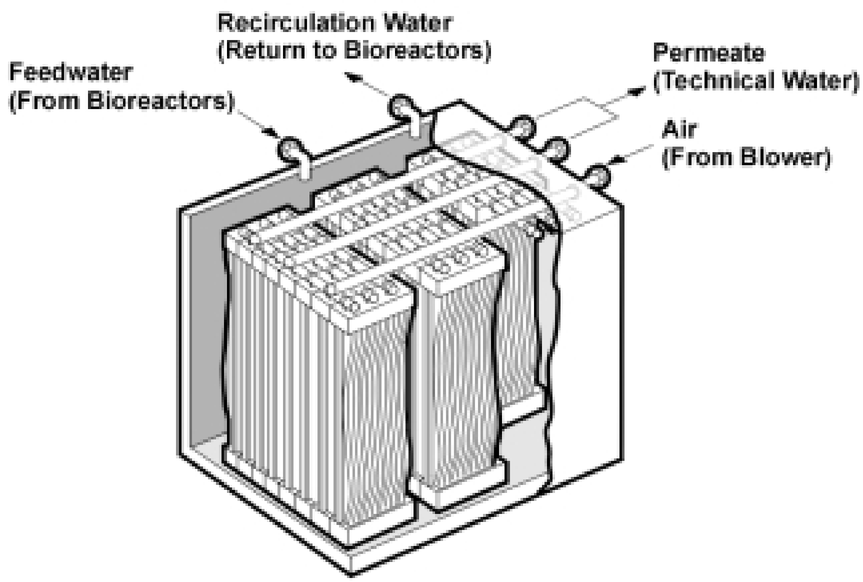

Figure 6. ZeeWeed® Membrane Tank

The ms Statendam system was commissioned in November 2000. To date it has been treating all black and gray water generated onboard while sailing in US and Mexican west coast, the Pacific Ocean, Hawaiin and Alaskan waters. HALW ship engineers have been checking effluent quality on a regular basis and confirmed that effluent quality of the ms Statendam system far exceeds the discharge standards listed in Table 1.

Table 2 shows the effluent quality tested by independent laboratories located in San Diego, USA and Vancouver, Canada, as overseen by HALW. Note that a continuous 7-day testing program was implemented in early 2001 to confirm the effluent quality and an effluent quality monitoring program was implemented for IMO/US Coast Guard certification. All tests have concluded that ZeeWeed® permeate quality exceeds the requirements of the existing regulations set by IMO, US Coast Guard, Miami Dade County criteria and Alaska State’s House Bill HB 260.

Table 2: Effluent Quality of ms Statendam System

Sampling date	BOD_5 (mg/L)	TSS (mg/L)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Nov-03-00	ND	ND	--	--
Nov-13-00	4.3	--	<2	<2
Jan-20-01	ND	ND	<2	<2
Jan-21-01	2.4	ND	<2	<2
Jan-22-01	ND	ND	<2	<2
Jan-23-01	ND	1.5	<2	<2
Jan-24-01	ND	ND	<2	<2
Jan-25-01	ND	ND	<2	<2
Jan-26-01	ND	1.4	<2	<2
June-04-01	BDL	BDL	7	<1

Note: ND – non detected.
BDL – below detection limit.

Case 2: Zaandam System

Successful commissioning of the ms Statendam system demonstrated the feasibility and simplicity of the ZenoGem® systems for shipboard application. Additionally, the excellent permeate quality proved that ZenoGem® effluent is able to meet the requirements of today and tomorrow's regulations. Following this, HALW decided to retrofit additional ZenoGem® systems onto its ms Zaandam and ms Volendam vessels, by converting spare potable water tanks into two bioreactor/ ZeeWeed® tanks, to treat both black and gray water.

The ms Zaandam system is quite different from the ms Statendam system, which consists of two completely independent ZenoGem® trains, i.e. two separate bioreactor tanks with ZeeWeed® membrane chambers. The ms Zaandam system incorporates the ZeeWeed® membrane chambers as a part of the bioreactors and are integrated into existing potable water tanks. Pre-screening equipment is also used because raw black water is introduced into the bioreactors directly from EVAC vacuum collection systems as opposed to old existing black water treatment plants. The existing black water plants are converted into solids holding tanks. Air is applied through an aeration grid in the bioreactor to provide necessary dissolved oxygen.

Figure 7 shows a conceptual flow diagram of the ms Zaandam system.

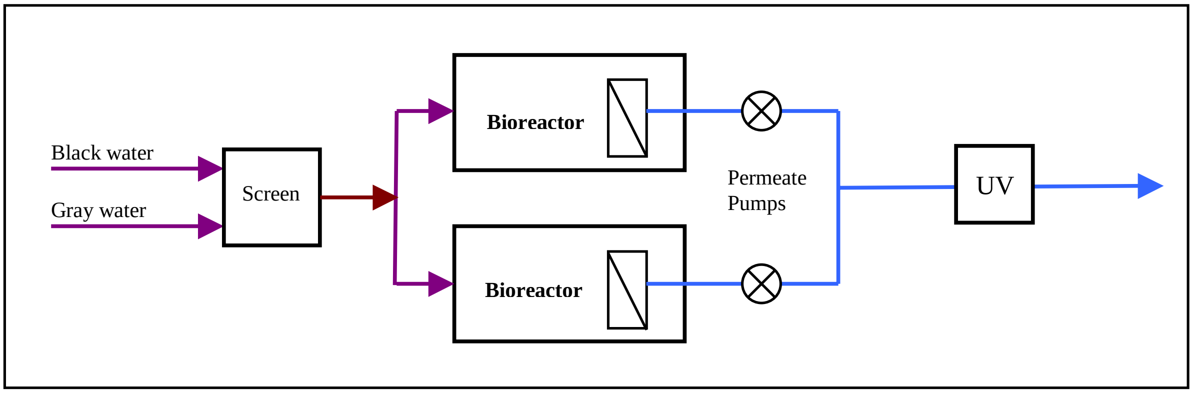

Figure 7: Conceptual Process Flow Diagram of the ms Zaandam System

With experience gained from the ms Statendam system, the ms Zaandam system was installed and commissioned very quickly, and occurred while the ship was still engaged in normal operations. System design was completed with this new retrofit concept by the end of February 2001 and the system started producing quality permeate in mid-May 2001. The system has been operating at full capacity since mid-July 2001.

Permeate quality has been under close monitoring. Table 3 shows the permeate quality tested by independent laboratory selected by HALW. As predicted, permeate quality has always been excellent. A continuous permeate quality monitoring program was also implemented for IMO/US Coast Guard certification starting in July 2001.

Success of the ms Zaandam system is an example of how fast and efficiently the ZenoGem® system can be retrofitted into a cruise ship without interrupting day-to-day ship operations or schedules.

Case 3: Ryndam Systems

Quick installation and commissioning of the ms Zaandam system not only reconfirmed the feasibility of ZenoGem® systems for shipboard applications but also demonstrated the suitability/adaptability of ZenoGem® systems under different conditions. Operational experience of HALW crews on the ms Statendam and ms Zaandam has also proven the simplicity and reliability of ZenoGem® systems. Therefore, HALW decided to retrofit two more ships, ms Ryndam and ms Veendam, with ZenoGem® systems.

The ms Ryndam system is similar to the ms Zaandam system. In this case, two existing potable water tanks are converted to bioreactor/ZeeWeed® tanks. Similarly, the ZeeWeed® membrane chambers are included in the bioreactor tank. However, in this case, two ZeeWeed® membrane trains share a common bioreactor.

The project is under process with commissioning of these two plants occurring in the Winter of 2001 and Spring of 2002.

Table 2: Effluent Quality of ms Zaandam System

Sampling date	BOD_5 (mg/L)	TSS (mg/L)	Total Coliform (CFU/100 ml)	Fecal Coliform (CFU/100 ml)
Jul 23-01	5	<1	BDL	BDL
Jul 24-01	2	<1	BDL	BDL
Jul 25-01	3	<1	BDL	BDL
Jul 26-01	4	<1	BDL	BDL
Jul 27-01	5	<1	BDL	BDL
Jul 28-01	5	<1	BDL	BDL
Jul 29-01	4	<1	BDL	BDL
Jul 30-01	2	<1	BDL	BDL
Jul 31-01	2	<1	BDL	BDL
Aug 01-01	3	<1	BDL	BDL
Aug 02-01	3	<1	BDL	BDL

Note: Total Coliform & Fecal Coliform were recorded at BDL – below detection limit of <10

SLUDGE HANDLING

Like conventional biological plants, membrane bioreactor systems generate a certain amount of bio-sludge that consists of microorganism, non-biodegradable organics and inorganic inert solids. Sludge generation rates vary from 1% to 5 % of influent flow rate, depending upon organic strength and solid content of raw wastewater and system design. Given the high MLSS concentration in the bioreactors, ZenoGem® systems generates much less sludge than conventional biological systems.

With the growing trend of "zero discharge," it is a challenge to handle the sludge within limited space available onboard ships. In order to simplify the system configuration, the following scenarios are generally considered:

Holding and Discharge to Sea

Holding-and-discharge approach is the simplest option. Sludge generated in the bioprocess can be held in the bioreactors or transferred to aerated sludge holding tanks and then discharged to open sea once the ship is in unrestricted waters, e.g., 12 miles off shore. With the use of screening equipment, all plastics (if any) are removed from the raw wastewater streams, so that the biological sludge is eligible to be discharged to open sea. The small amount of solids rejected by screening equipment can be disposed off when the ship is along side or incinerated onboard.

Sludge holding time depends upon the organic strength and the volume of the bioreactors and/or the sludge holding tanks. Since the sludge generation rate is only 1-5% of the wastewater generation rate, a very small tank can hold the sludge for many days.

Thickening, holding and discharging to land.
If raw black and gray water streams contain plastics and no screening equipment is installed prior to the bioreactor, the bio-sludge is not eligible to be discharged to the open sea. It would be necessary to remove the plastics (i.e., by screening) before discharging to sea or to discharge the bio-sludge to land for further treatment.

In case of land disposal, sludge thickening needs to be considered in order to increase onboard sludge holding time.

Thickening, dewatering and incinerating onboard.
The most favored option for sludge handling is "zero-discharge". In this case, all sludge generated onboard is incinerated and there is no sludge to discharge. The biological sludge needs thickening and dewatering to further reduce sludge volume and to meet the requirements for incineration. Polymer addition may also be required for sludge conditioning prior to thickening and dewatering.

CONCLUSIONS

The marine version of the ZeeWeed® ZenoGem® system is a proven technology for shipboard black and gray water treatment. ZenoGem® effluent has been proven, through extensive monitoring and testing programs, to far exceed the requirements of all the existing regulations. ZenoGem® systems installed on HALW vessels have passed IMO and US Coast Guard certification criteria.

Retrofitting concepts and techniques, which ZENON Environmental Inc. has developed and practiced can be, applied to all cruise ships, ferryboats and naval warships even though the selection of the retrofitting approach is very case dependent. Successfully retrofitting ZenoGem® systems on three different types of HALW vessels has demonstrated the adaptability, simplicity and reliability of ZenoGem® systems for cruise ship applications.

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RETROFITTING SHIPBOARD GREY & BLACK WATER TREATMENT SYSTEMS USING IMMERSED MEMBRANE BIOREACTOR TECHNOLOGY

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ZENON
Water for the World

13 September 2001 Bremerhaven, Germany

Presentation Outline

- Introduction
  - Current Regulations
- ZeeWeed® ZenoGem® Technology
- ZenoGem® Shipboard Applications
- Retrofitting Concepts
- Case Studies
- Sludge Handling Concepts

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Water for the World

ZENON Environmental

- Founded in 1980
- Public Company traded on the Toronto Stock Exchange
- FY'00 Revenues of >CDN$100 Million
- 100% focused on membrane-based water and wastewater treatment systems
- 500 Employees
- Offices in Brazil, Canada, Germany, Hungary, Italy, UAE, UK, USA, and Singapore
- Took reverse path by starting with sewage treatment, then water treatment

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Supplying MBR systems since 1983

Current Marine Regulations

Table 1: Current Marine Regulations

Parameters		IMO	US Coast Guard	Miami Dade Code	US Navy	Alaska Standard	Title 22 California *	Canadian Coast Guard **
BOD5	Mg/L	50	50	30	50			20
TSS	Mg/L	50	150	40	100	150		20
Fecal Coliform	MPN/100ml	200	200	0	200	200		20
Total Coliform	MPN/100ml			1000			2.2	

* Disinfected tertiary recycled water defined in Section 60301.230, Title 22 Code of California Regulation.
** Non - official

ZeeWeed®

- Patented hollow fiber membrane
- Shell-less, ultra-low energy operation
- Polymeric, hydrophilic, chlorine tolerant
- Ultrafilter (nominal pore size = 0.035 micron)
- Commercialized in 1992
- Over 50-million gallons per day of installed capacity
- Suction induced flow
- Self cleaning

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ZeeWeed® Membrane

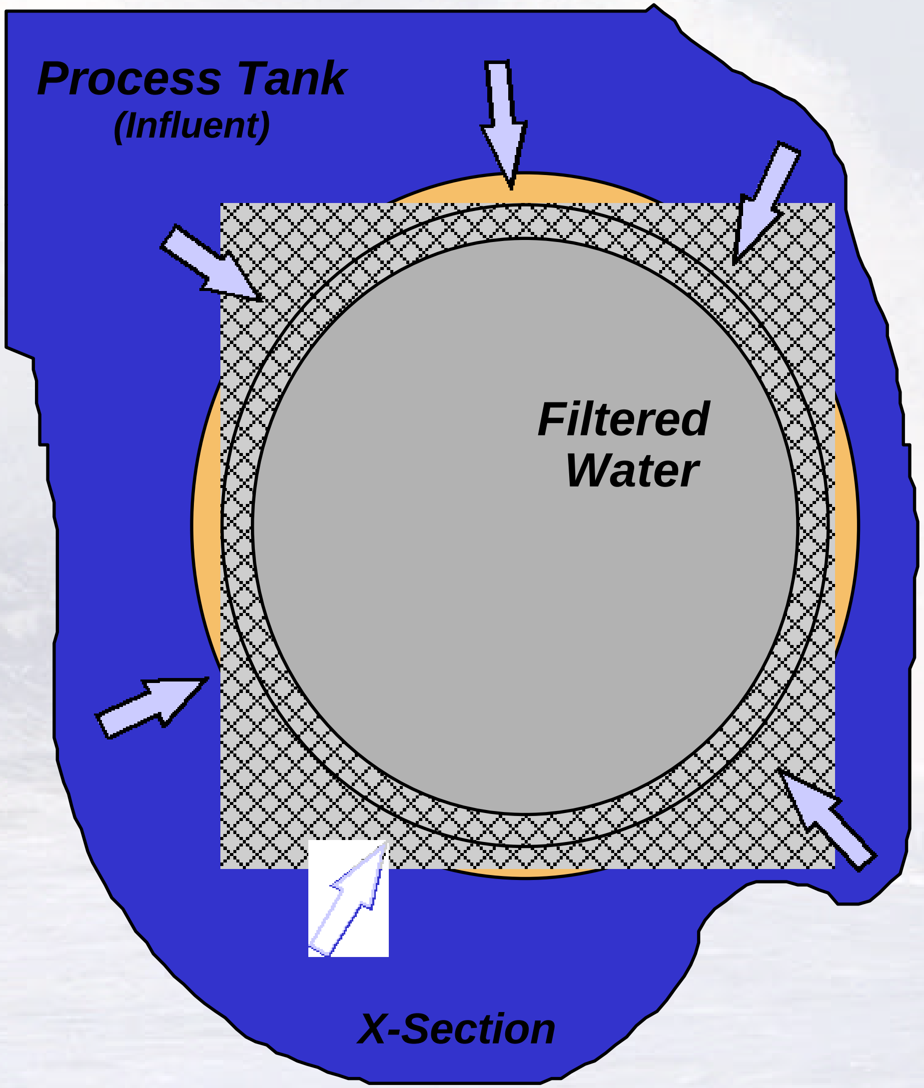
Immersed, Ultra Low Pressure, Oxidant Resistant, High Strength

Inner reinforcing structure covered with a composite polymer outer layer

Pore Size
0.035 micron (nominal)
0.1 micron (absolute)

Diameter
Outer = 1.9 mm
Inner = 0.9 mm

Operates at -2 psi to -5 psi when filtering and +8 psi on backwash



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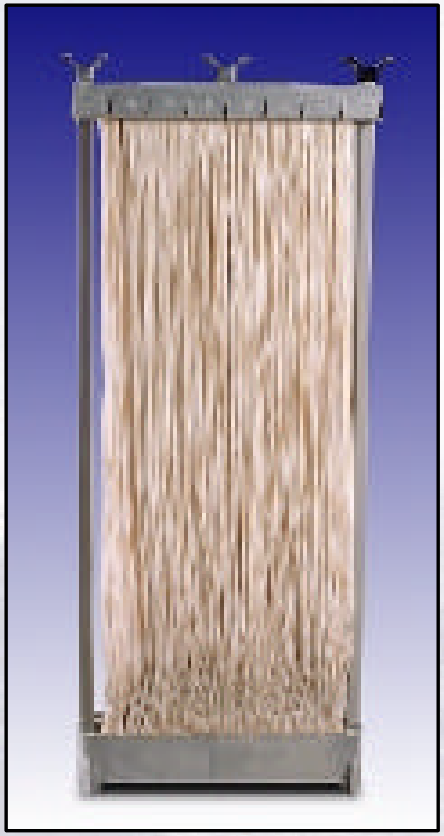
ZeeWeed® ZW500 Hollow Fiber Membrane



ZW 500a Module

ZW 500c Module

ZW 500c Cassette

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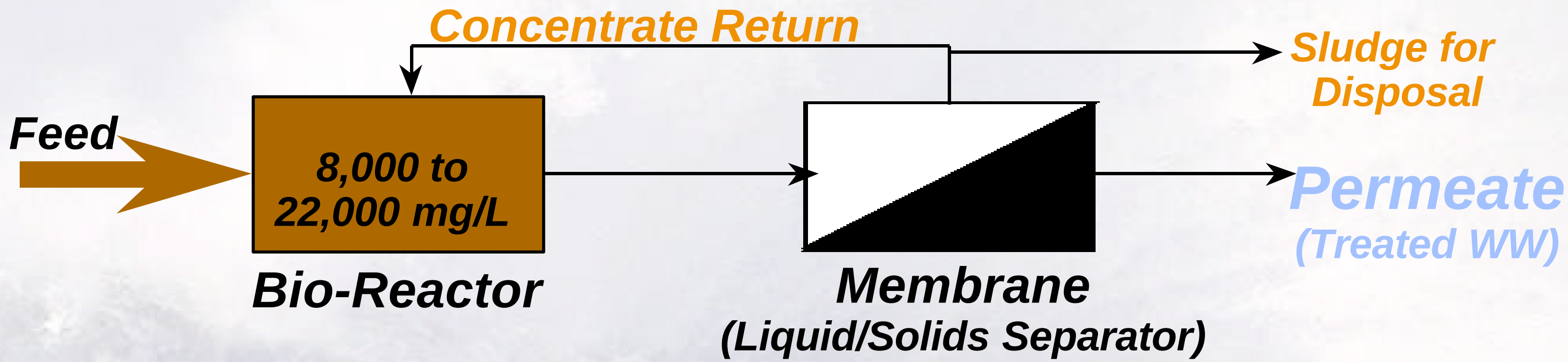
ZenoGem®

Membrane Bioreactor (MBR)



Hi-Rate Bioreactor

•large capacity throughput

•compact footprint

•tertiary treatment

•simpler reliable process (de-emphasizes biological component)

Absolute - Positive Filter

•high degree of organisms/solids control

•consistent effluent quality

•lower operator attention - fewer components

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ZeeWeed®
Immersible Outside-In Membrane

ZENON
Water for the World

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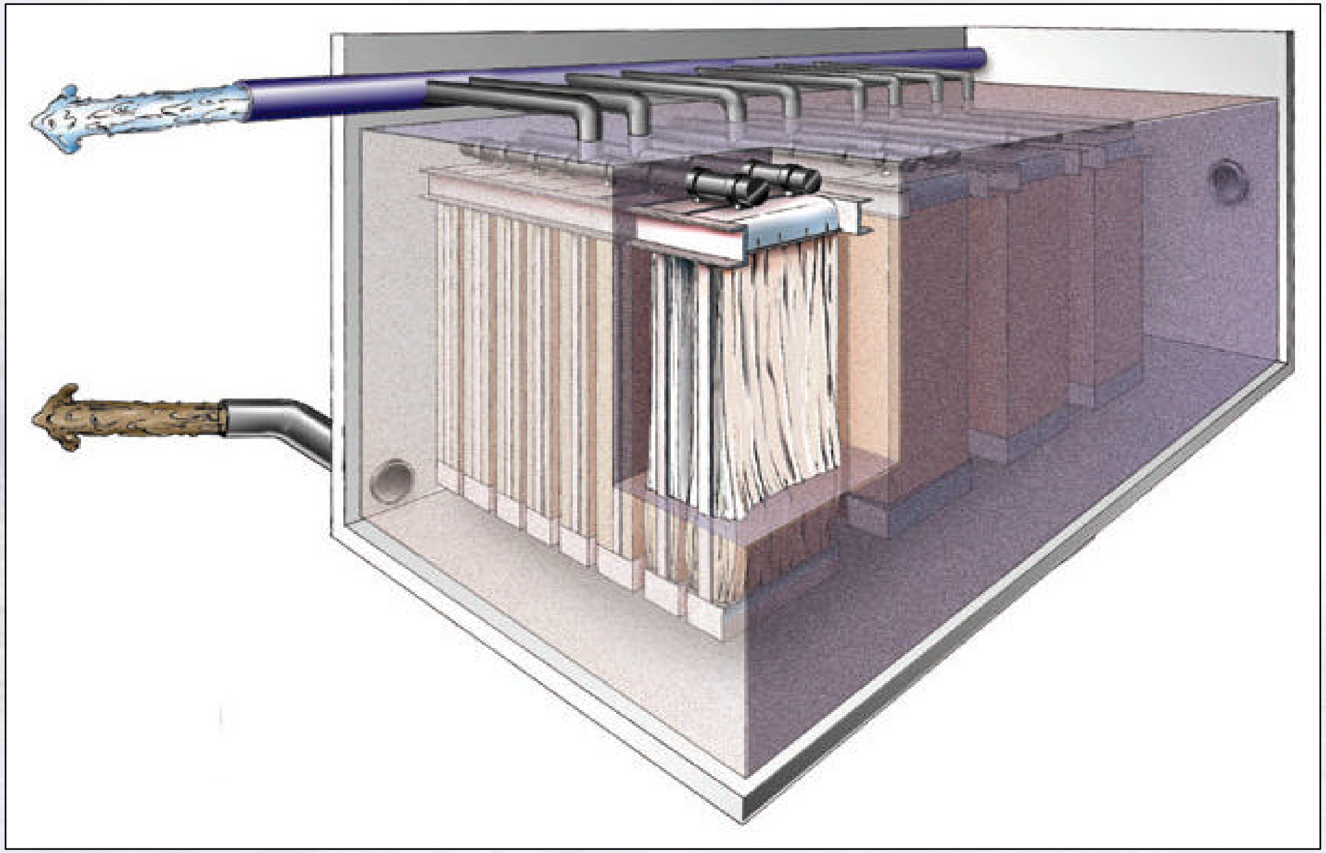
The ZeeWeed® Immersed Hollow Fibre Configuration Represents a Breakthrough in Shipboard Wastewater Treatment



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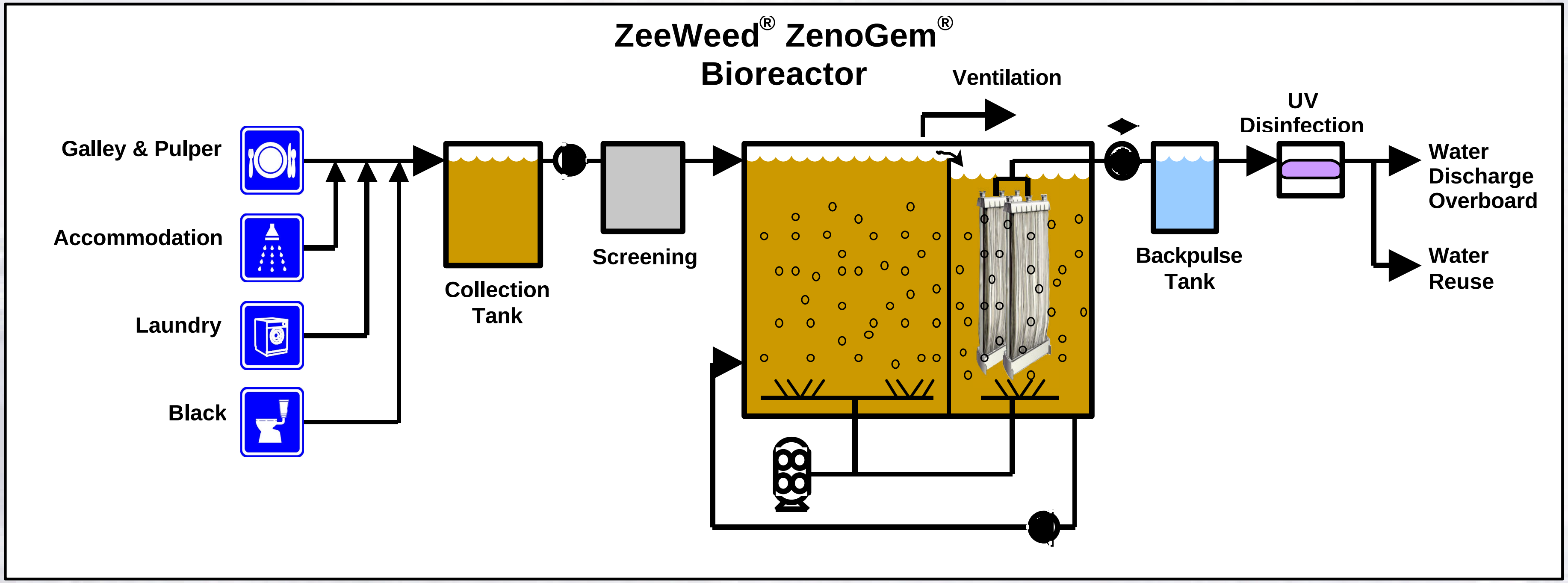
ZeeWeed® ZenoGem® Technology Shipboard Process Design



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ZeeWeed® Shipboard Applications

Operational Conditions

- High Waste Strength implies Large System
- Limited Tank Volume and Depth
- High Influent Temperature
- High Ambient Temperature
- Operational Simplicity

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ZeeWeed® Shipboard Applications

ZeeWeed ® Advantages for Shipboard Application:

Immersed membranes require smaller footprint

High MLSS operation requires smaller reactor volume

Modular expandability

Accurate control over sludge age

Single unit operation

Effluent BOD, N, P, TSS levels meet today's and anticipated future standards

Effluent TSS (0.035 micron filter) independent of bio-reactor efficiency, biosolids settling characteristics

Phosphorous removal capability for ports requiring it

Positive bacteria retention ensures high population for treating slug or toxic loads

Retrofitting Concepts

Option 1:

- Converting Potable Water Tanks
  - Often available, oversized, under utilized
  - Typically large
  - Easily converted = Aeration grid + ZeeWeed ®
  - Savings in Space & Costs
  - Installation underway

ms Zaandam & Volendam are Examples

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Retrofitting Concepts

Option 2:

- Replacing Sewage Treatment Plants
  - Typically 3-4 BW Plants onboard
  - Treat Diluted BW
  - Process tank + clarification
  - HOWEVER, sensitive to influent quality and dilution control
  - Can become unreliable to consistently meet standards
  - ZeeWeed® inserted in tanks give much higher capacity
  - Can treat all gray + black
  - Multiple systems offer treatment flexibility

Retrofitting Concepts

Option 3:

- Replacing Blackwater Physical Chemical Systems
  - Hold-Dilute-Disinfect
  - Consist of holding tanks + seawater dilution + hypochlorite injection
  - Effluent may contain high amount of chlorine
  - Treat Diluted BW
  - Can be replaced with ZenoGem® system by converting tanks + other ships tanks

Retrofitting Concepts

Option 4:

- Using Double Bottom Tanks
  - Often used for Graywater or Ballast water
  - Large in Volume but short height + internals
  - Flow restrictions plus corrosion concerns
  - HOWEVER, are viable if limited options
  - Corrosion protection + Novel O_2 transfer

ms Statendam Successfully Retrofitted

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Retrofitting Concepts

Option 5:

- Construction New Tanks
  - Challenged to find space
  - Storage areas often considered
  - Shape not critical
  - Can be built onto hull in non uniform shape

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Retrofitting Concepts

<u>Options:</u>

1. Converting Potable Water Tanks
2. Replacing Sewage Treatment Plants
3. Replacing Blackwater Physical Chemical Systems
4. Using Double Bottom Tanks
5. Construction New Tanks

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Case Study

US Navy - AMTS

Case 1: ms Statendam System

Case 2: ms Zaandam System

Case 3: ms Ryndam System

Case Study

Case 1: ms Statendam System

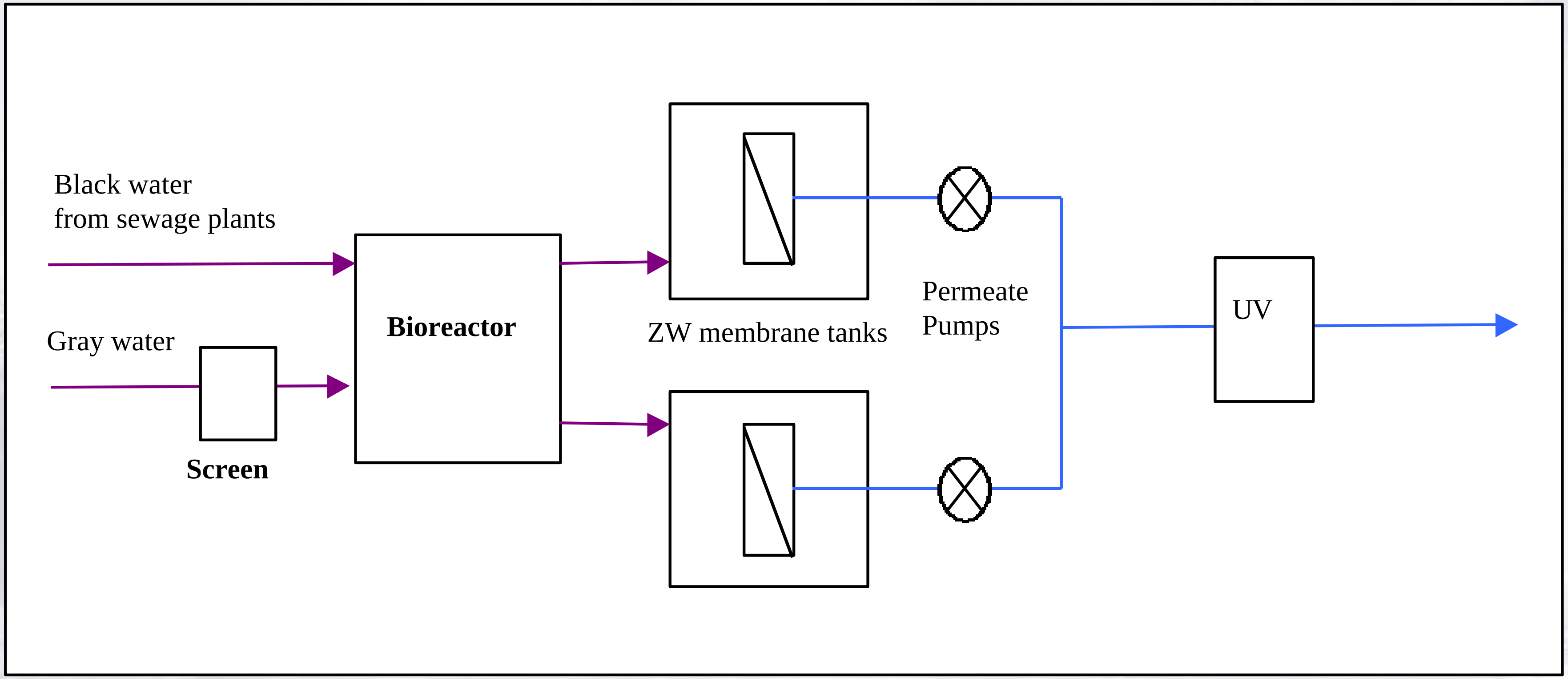
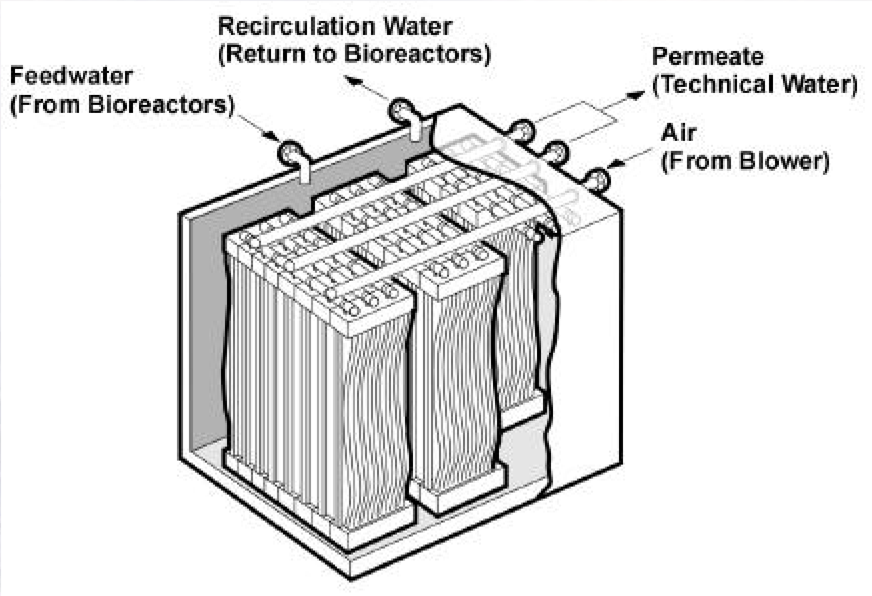


Figure 5: Conceptual Process Flow Diagram of ms Statendam System

Case Study

Case 1: ms Statendam System

- Two Double Bottom Tanks
- Two ZeeWeed® Tanks
- Treats all Gray including "Somat" effluent
- Oxygen generation
- Consist of:
  - 6 pumps
  - 2 blowers
  - 2 O_2 Gen sets
  - 1 UV



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Case Study

Case 1: ms Statendam System

Table 2: Effluent Quality of ms Statendam System

Sampling date	BOD_5 (mg/L)	TSS (mg/L)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Nov-03-00	ND	ND	--	--
Nov-13-00	4.3	--	<2	<2
Jan-20-01	ND	ND	<2	<2
Jan-21-01	2.4	ND	<2	<2
Jan-22-01	ND	ND	<2	<2
Jan-23-01	ND	1.5	<2	<2
Jan-24-01	ND	ND	<2	<2
Jan-25-01	ND	ND	<2	<2
Jan-26-01	ND	1.4	<2	<2
June-04-01	BDL	BDL	7	<1

Note: ND – non detected.
BDL – below detection limit.

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Case Study

Case 2: ms Zaandam System

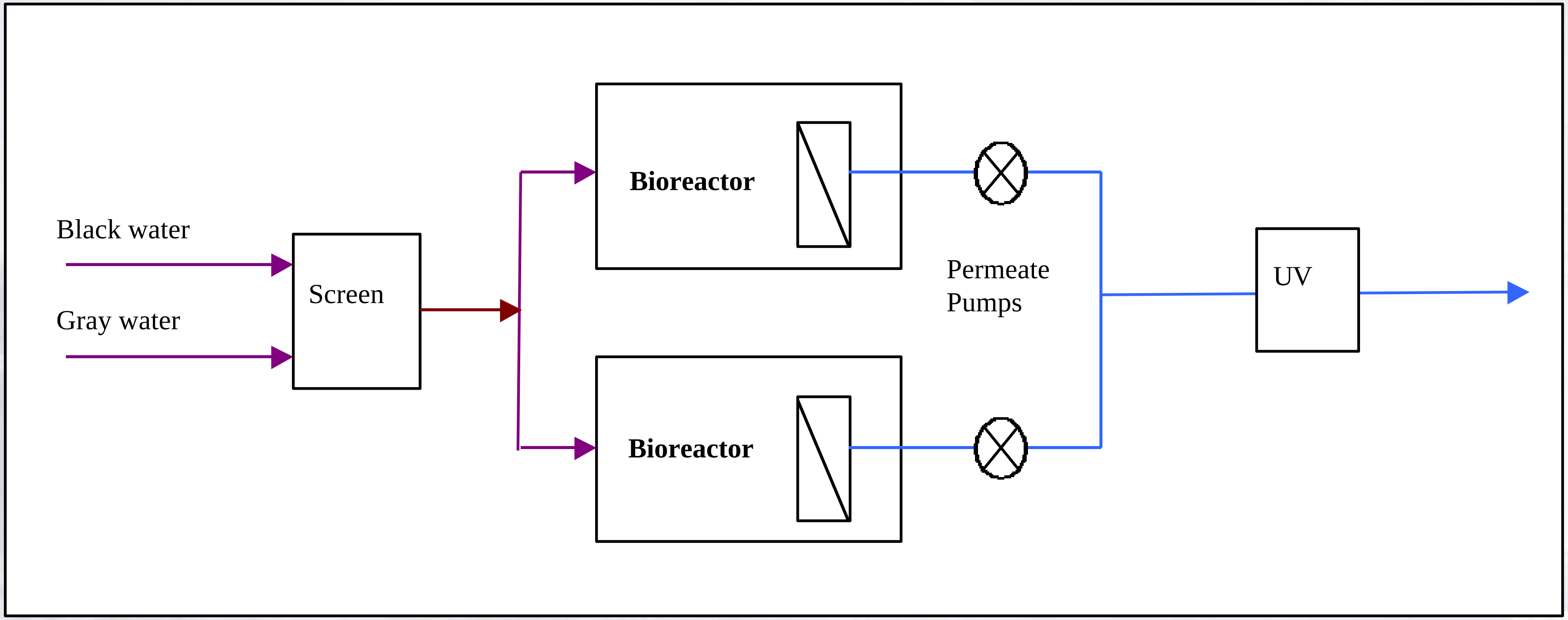

Figure 7: Conceptual Process Flow Diagram of the ms Zaandam System

Case Study

Case 2: ms Zaandam System

- Utilize Spare Potable Water Tank
- Two ZenoGem® Trains
- Membrane Chambers inside Bioreactors
- Converted existing MSD for Prescreening & solids collection tanks

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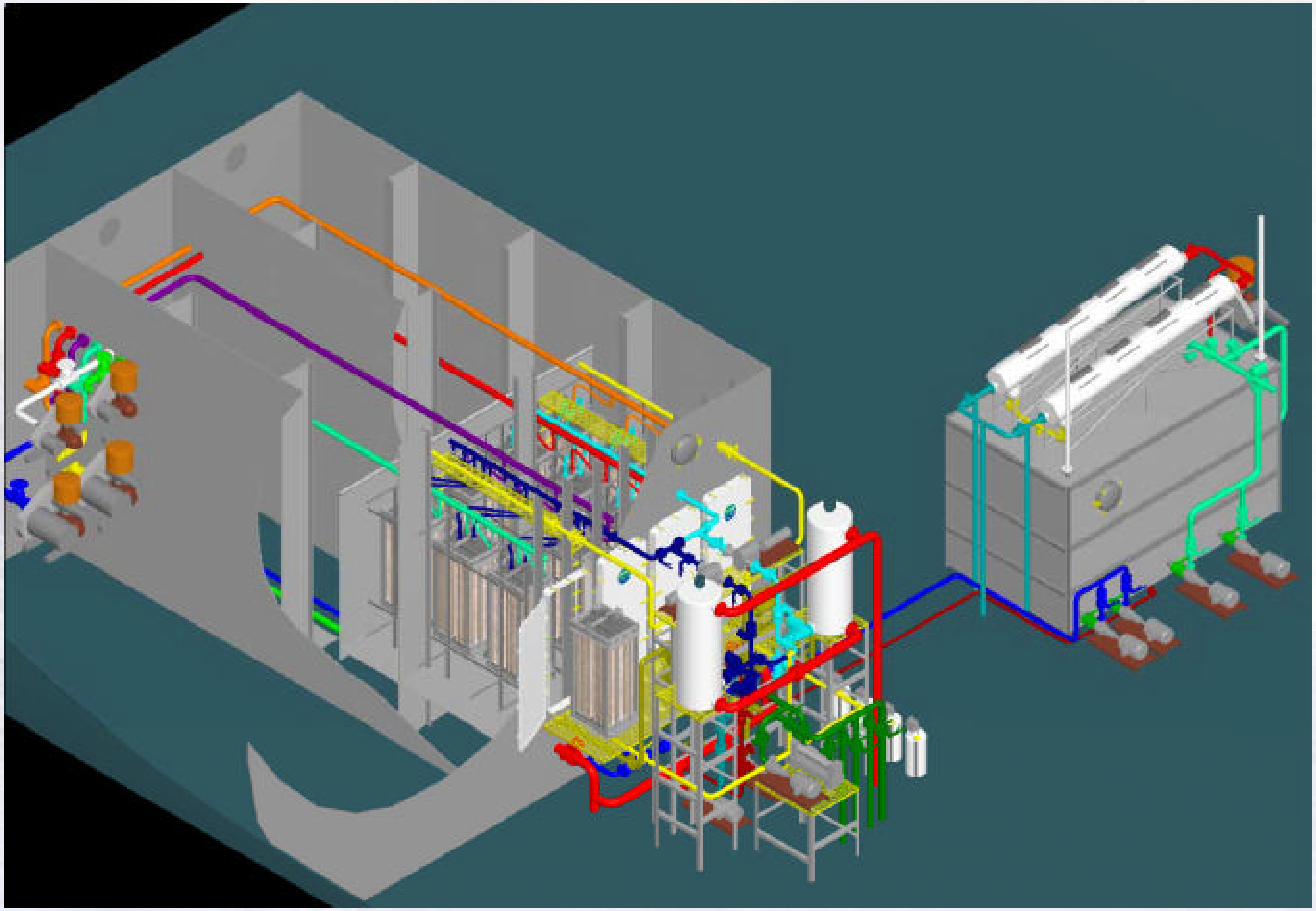
Case Study

Case 2: ms Zaandam System



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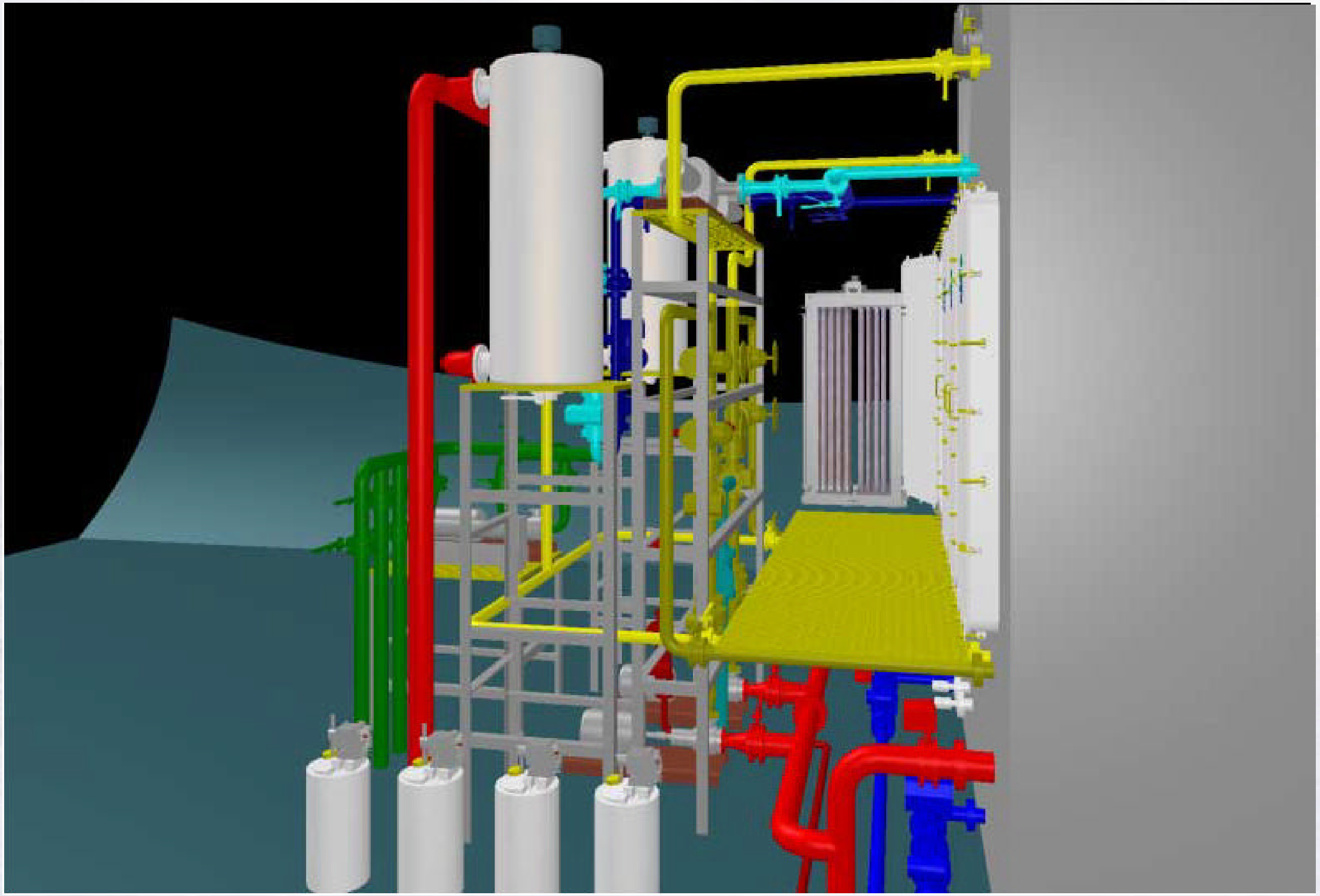
Case Study

Case 2: ms Zaandam System



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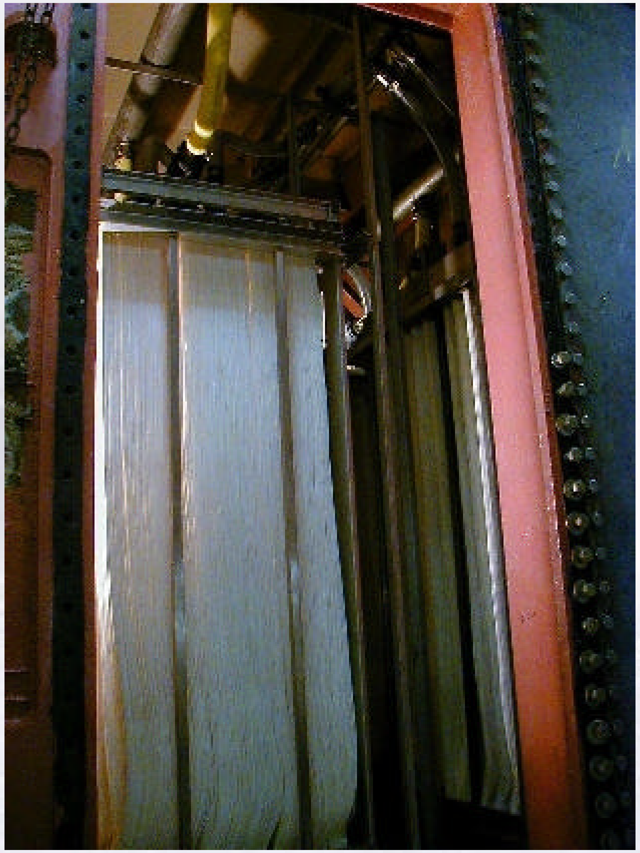
Case Study

Case 2: ms Zaandam System

Machinery Space

Membranes



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Case Study

Case 2: ms Zaandam System

Table 2: Effluent Quality of ms Zaandam System

Sampling date	BOD_5 (mg/L)	TSS (mg/L)	Total Coliform (CFU/100 ml)	Fecal Coliform (CFU/100 ml)
Jul 23-01	5	<1	BDL	BDL
Jul 24-01	2	<1	BDL	BDL
Jul 25-01	3	<1	BDL	BDL
Jul 26-01	4	<1	BDL	BDL
Jul 27-01	5	<1	BDL	BDL
Jul 28-01	5	<1	BDL	BDL
Jul 29-01	4	<1	BDL	BDL
Jul 30-01	2	<1	BDL	BDL
Jul 31-01	2	<1	BDL	BDL
Aug 01-01	3	<1	BDL	BDL
Aug 02-01	3	<1	BDL	BDL

Note: Total Coliform & Fecal Coliform were recorded at BDL – below detection limit of <10

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Case Study

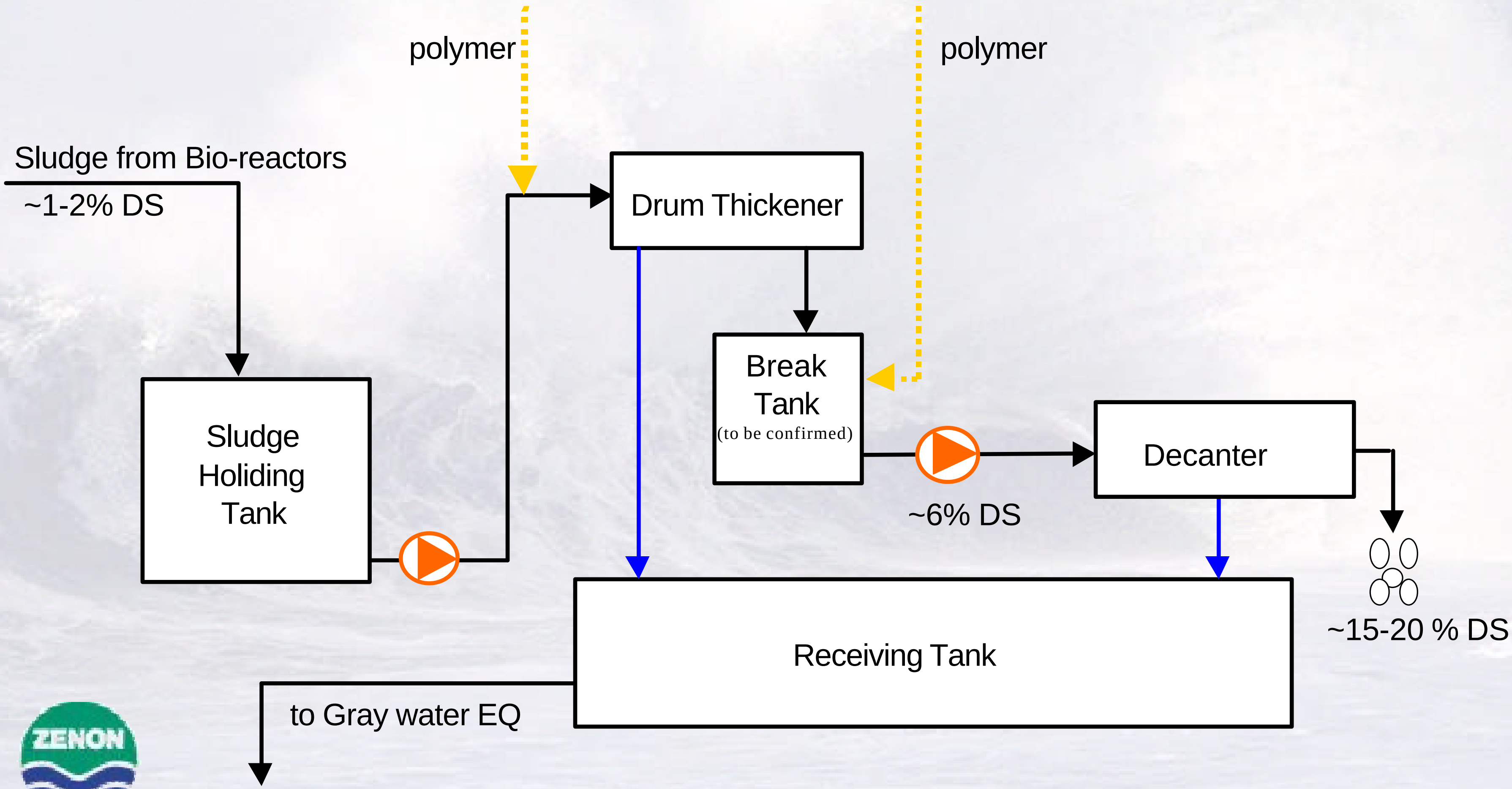
Case 3: ms Ryndam System

- Case 2 project confirmed ease of installation
- Retrofitted ms Ryndam & Veendam
- Similar concept to Zaandam class
- Share common Bioreactor vs. two separate units

SLUDGE HANDLING

- What do you do with the Sludge????
  - Holding and Discharging to Sea
  - Thickening, Holding and Discharging to Land
  - Thickening, dewatering & incinerating onboard

SLUDGE HANDLING
Design Concept



CONCLUSION

- ZenoGem® proven technology
- Easily adaptable for retrofit situation
    - In existing tanks
    - In existing MSDs
    - New tank construction
- Design exceeds IMO & Coast Guard Criteria

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CURRICULUM VITAE

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Oktober 1985 – August 1992 Technical University of Clausthal, Germany
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Topic of the Diploma Thesis:
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Profession:

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BUC Umweltconsulting, Hanover, Germany
Project Engineer – Biological Waste Treatment

Oktober 1994 – April 1999
Technical University of Clausthal, Germany
Mass Transfer Laboratory (Professor Vogelpohl)
Scientist, special focus on:

- Biological Wastewater Treatment Systems
- Membrane Systems
- Flotation

Thesis for Doctoral Degree (Dr.-Ing.):
"Study of the Recovery and Reuse of Organic Substances from Industrial Wastes and Wastewater"

May 1999 – March 2001
TECON CHEMICALS, Clausthal, Germany
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- Design / Start-Up Wastewater Treatment Plants
- Development /Marketing of Chemicals/Additives for Biological Wastewater Treatment

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Abstract

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"The Optimal Solution for Liquid Waste Treatment Onboard Ships - Grey Water and Black Water "

Liquid wastes, especially Grey Water and Black Water, become more and more a serious environmental problem onboard ships for reasons of stricter international rules and regulations. The daily amount of liquid wastes onboard a 4500 passenger cruise ship is approx. about 1500 t.

Until now these liquid wastes are collected in tanks and discharged into the sea outside the 12 miles zone, sometimes pre-treated biologically and/or chlorinated for disinfection.

Biological systems in combination with membranes or membrane systems alone (e.g. Reverse Osmosis) have to be well designed and require 24 h/d experts for a reliable operation, otherwise they do not work at all onboard ships.

In order to supply the owner the optimal solution and the most reliable and simple to operate system for Liquid Waste treatment DEERBERG cooperates with Hydroxyl Systems (Sydney, B.C., Canada) and implements the Hydroxyl CleanSea™ Process into DEERBERG-SYSTEMS Multi-Purpose-Waste-Management-System.
The Hydroxyl CleanSea™ Process is a combination of:

- Solid-Liquid Separation by the Positive Flotation Mechanism (PFM)
- Advanced Oxidation Process by using O_3 to degrade soluble organic pollutants
- Sludge Dewatering for Incineration.

For larger vessels a combination with a Fixed Film Biology may be also useful.

The effluent of the process is supersaturated with Oxygen and disinfected. The reuse of waste water onboard ships e.g. for technical water, toilet flushing or laundry purposes becomes possible.

The Hydroxyl CleanSea™ Process will be introduced and design examples as well as performance data onboard ships will be presented.

The Optimal Solution for Liquid Waste Treatment Onboard Ships
- Grey Water, Black Water -

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1. Introduction

Liquid wastes, especially Grey Water and Black Water, become more and more a serious environmental problem on board ships for reasons of stricter international rules and regulations. The estimated daily amount of liquid wastes on board a 4500 passenger cruise ship is in the range of about 1500 t.

Until now these liquid wastes are collected in tanks and discharged into the sea outside the 12 miles zone, sometimes biologically pre-treated and/or chlorinated for disinfection.

In order to supply the owner the optimal solution and the most reliable and simple to operate system for Liquid Waste treatment integrated into a complete waste management system on board cruise vessels DEERBERG-SYSTEMS did a comprehensive study about possible technologies and available systems.

Before discussing the results of the study a short introduction of the composition of the different liquid wastes, the definition of the main goals and requirements on a suitable treatment system will be given.

2. Grey and black water

The total amount of grey water on board a cruise vessel consists of grey water from galleys, hotel and laundry. Black water comes from the toilet system. Table 1 gives an impression of the wastewater composition and amounts of the single streams.

Grey and black water on board cruise vessels (main consumer)			
Waste stream	**Amount m^3/day**	**BOD_5 mg/l**	**TSS mg/l**
Black water	113	1390	1390
Galley grey water	135 - 203	600	600
Hotel grey water	743 - 945	200	150
Laundry grey water	108 - 203	150	100
Other grey water	68 - 135	-	-
Total amount per day	**1463**	**-**	**-**

Tab. 1: Estimated wastewater amount and composition of a 4500 passenger vessel (averages, deviations possible)

As seen from table 1 especially galley grey water is an important problem, as it contains the one of the highest daily loads of BOD and TSS of all relevant liquid waste streams. The high TSS and BOD is mainly caused by the pulper water as a part of galley grey water. This stream creates the most serious problems in treating grey water.

Black water is another important problem, as it has only 8 % of the volume of the total wastewater amount but it contributes 25 % of the daily BOD- and TSS-load.

In total the liquid waste treatment system onboard a 4500 passenger cruise vessel has to treat about 1500 m^3/d and remove approx. 0,5 tons/day of BOD_5 and TSS.

3. Goals for grey and black water treatment on board cruise vessels

As now grey water and pre-treated black water are collected in tanks and discharged into the sea outside the 12 miles zone the main goal of the treatment of liquid wastes is to avoid the discharge of un- or not properly treated wastewater into the sea. To secure to the owner a legal operation independent from where the cruise vessel is sailing, the effluent quality of an advanced liquid waste treatment system has to meet existing and future rules and regulations for discharge into the sea. Table 2 shows limit values of different regulations for the very important parameters BOD_5 (**B**iological **O**xygen **D**emand in **5** days), TSS (**T**otal **S**uspended **S**olids) and Fecal Coliform Bacteria.

Parameter	IMO Upper Limit Value	Miami Dade County	Alaska
BOD_5	50 mg/l	40 mg/l	30 mg/l
TSS	250 mg/l	30 mg/l	30 mg/l
Fecal Coliform	250 /100 ml MPN	0 /100 ml MPN	20 /100 ml MPN

Tab. 2: Limit values of different regulations

An additional goal for the treatment of liquid wastes on board a cruise vessel is the water recycling. Practicable seems to be the reuse of treated wastewater for technical purposes or toilet flushing. Possible streams for a recycling are e.g. laundry- and hotel grey water.

4. System requirements for grey and black water treatment

The following main requirements have to be met by a suitable and advanced liquid waste treatment system, also for new builds and for refits:

- ✓ Meeting the limit values to secure a legal and environmental friendly operation.
- ✓ Low space requirements.
- ✓ Modular concepts, especially for easy upgrading and refitting of existing vessels.
- ✓ Integration into a complete Waste Management System in order to avoid discharge of any residuals either to sea or to on-shore.
- ✓ Easy to operate and to maintain in order to save man-power and costs on board.

5. Possible technologies and available systems for grey and

black water treatment

Possible treatment technologies can be sub-divided into:

- Biological systems with mechanical separation of solids and disinfection
- Membrane systems
- Membrane-Bioreactor systems, either
  - External membrane filtration or
  - Submerged membrane filtration
- Wet Oxidation Systems, from case to case combined with a biological treatment step

The available systems for the treatment of grey and black water are processes which were originally developed for land-based applications and transferred to cruise vessels, resulting in several compromises concerning cleaning efficiency and/or reliability in operation. The table 3 gives examples of available systems of each treatment technology. In the following the most important advantages and disadvantages are discussed.

Technology	**Main supplier**
Conventional biological sewage treatment systems	Hamworthy, Triton Format
Membrane systems	Pall
Membrane-Bioreactor systems, external membranes	Rochem UF, Hamworthy KSE
Membrane-Bioreactor systems, submerged membranes	Zenon
Bioreactor + flotation	HOH
Wet oxidation system + flotation	Hydroxyl Systems

Tab. 3: Examples for available liquid waste treatment systems

The common biological treatment systems (3 or 4 chamber systems) are applied on board ships for a long time. They are simple to operate but the cleaning efficiency is poorer than other technologies. Especially the concentration of suspended solids in the effluent is higher than in the systems discussed below. To remove germs a disinfection of the effluent by chlorination is necessary. For those reasons these systems are not state of the art any more. They make only in such applications sense, where no other technology is available.

Membrane systems (e.g. reverse osmosis or ultrafiltration) for liquid wastes treatment lead to high effluent qualities as far as membranes with a suitable cut-off size and the types of modules and/or pre-treatment steps are chosen to meet the wastewater properties (e.g. in case of suspended solids a particle separation or tubular membranes are necessary in order to avoid blockages of the modules). Membranes do not remove the pollutants in the wastewater, they only separate the influent into a permeate with a very low concentration of pollutants and a concentrate with a high concentration of pollutants (depending on the cut-off size).The concentrate has to be collected and discharged separately. The amount of liquid waste to be discharged (i.e. the concentrate) will be considerably reduced, but not the daily load of pollutants.

Biological systems in combination with membranes are characterized by high effluent quality, as total rejection of particles and germs is possible as well as the decoupling of wastewater and substrate retention time, which leads to further degradation even of those pollutants which are difficult to degrade biologically [1]. But these systems have to be well designed and require 24 h/d experts for a reliable operation, otherwise the biodegradation is poor, permeate flux will decrease rapidly, which leads to high maintenance efforts for membrane cleaning. One important aspect is the reactor design and it’s aeration system in order to achieve high mass transfer efficiency for oxygen as sufficient oxygen supply is the basis for a biological degradation of organic wastewater pollutants. Furthermore the biological surplus sludge production is another problem, as the sludge has to be dewatered (about 99 % water in the sludge) and incinerated or collected separately and discharged.

Flotation for particles separation from liquids (separation off small particles and flocs, e.g. biomass) is a well known process The effectiveness of a particle separation by flotation depends especially on the size of gas bubbles. The smaller the bubbles are, the better are the chances to achieve a good separation result. The bubble size can be influenced by the surface tension of the gas bubbles against the surrounding liquid and by the method the gas is dispersed into the liquid. To improve the flotation often surfactants and polymers are used. The HOH-process uses flotation for particles separation after the biological cleaning step, the CleanSea™ Process by Hydroxyl Systems also as an effective pre-treatment step.

Wet oxidation technologies use an oxidant for the degradation of organic pollutants. On example for this technology is the above mentioned CleanSea™ Process. This process is a combination of a solid-liquid separation by flotation, oxidation by using O_3 produced from ambient air and sludge dewatering for incineration. For larger vessels a combination with a bioreactor may be also useful. The system is easy to operate and it is the only process with an effluent which is saturated with Oxygen and disinfected. The concentration of suspended solids in the effluent is higher than in a permeate of a membrane system, but still below the above mentioned limit values. As Ozone is not stable in storage it has to be produced on board which requires special equipment. As Ozone is unhealthy to inhale a special detection- and destruction system is necessary.

Last but not least one very important aspect has to be mentioned. All biological systems are very sensitive to inorganic chemicals applied for cleaning purposes on board the ship. High concentrations of these cleaning products in a bioreactor will reduce or even stop biological activity. In addition these chemicals will be discharged into the sea.

6. Comparison of the advanced technologies

Table 3 shows a comparison of advantages and disadvantages of main technologies.

Technology	Main Advantages	Main Disadvantages
Conventional sewage treatment systems	-simple to operate	-poor cleaning efficiency -chlorination for disinfection necessary -sludge to be handled
Membrane systems	-high effluent quality (germ free) -reuse of water possible	-very sensitive to suspended particles in the wastewater -concentrate to be treated separately -skilled and experienced operators necessary -high maintenance -membrane replacement very expensive
Membrane bioreactor	-high degradation rates -high effluent quality (germ free) -modular systems	-skilled and experienced operators necessary -high maintenance -membrane replacement very expensive -surplus sludge to be handled
Bioreactor + flotation	-also treatment of bilge water is specified to be possible	-effluent not particle free -additional disinfection necessary
Wet oxydation + flotation	-very effective removal of suspended solids by flotation -effluent disinfected and Oxygen saturated - combination with fixed film bioreactor possible	-handling of pure Oxygen and Ozone -effluent not particle free

Tab. 3: Comparison of the main technologies

7. The optimal solution

An idea for the optimal solution, especially on large cruise vessels could be a combination of different technologies by using the main advantages of wet oxidation, biological systems and membranes. Furthermore this combination should not be discussed as a “end-of-the-pipe” solution, but to (pre-)treat single liquid waste streams in the best way. Of course the different systems have to be linked to each other.
For example could be the highly polluted galley grey water and the black water treated in an membrane bioreactor system, especially as they should not be recycled for aesthetic reasons. The solids in the water could be separated before by a small flotation unit and after dewatering fed into the incineration system.
The lower polluted streams from hotel and laundry could be treated in a wet oxidation system. This approach allows, if necessary in combination with a membrane separation as a last polishing step the reuse or even recycling of single liquid waste streams. An idea could be e.g. the reuse of treated hotel grey water for toilet flushing or the recycling of laundry water.
In addition a proper integration of the liquid waste treatment system into the complete waste management system on board is necessary, e.g. for handling and treatment of the solid residues of the liquid waste treatment system.

8. Conclusion and outlook

The study shows that there are different technologies possible and several systems available. All advanced systems have advantages and disadvantages. The <u>optimal</u> solution could be a combination of wet oxidation systems with bioreactors and membranes and depends on amounts and composition of each wastewater stream on board. This optimal solution has to be a tailor made concept for each ship.

A first step to improve the situation on board is the replacement of hazardous inorganic cleaning chemicals by environmental and application friendly biological cleaning products, e.g. Hepburn Bio Ship Care.

The most important result is the necessity to develop and install a solution integrated into a complete waste management system as DEERBERG-SYSTEMS is working on and not an isolated process.

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Chem. Ing. Tech. (1997) 7, 996 - 999

CURRICULUM VITAE

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Education:

B.S. Mechanical Engineering	McGill University (Chem. E. optional year program)
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Business B.Commerce	George Williams College, Concordia University
Diploma	U.C. Redlands Soil Remediation and UST Design and Removal
Lecturer	UCLA Extension - Downtown Environmental Engineering Course. Lectured in "The Treatment Techniques used in Industry and POTW's"

LICENSES

Registered Professional Engineer :	California, Arizona, British Columbia, and Quebec.
California State Contractors Board :	"A" General Engineering Contractor, "B" General Building
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California State Licence:	"ASB" Asbestos Removal, and "HAZ" Hazardous Materials Removal

Engineer – chief, Benchmark Inc. Anaheim, CA. Directed engineering group in the design and construction of wastewater process plants in the Oil, Chemical, and Food industry.
Senior Engineering Field Manager for installation of wastewater plants within the Electronics Industry.

Director of Engineering, Ramsey, Nickerson, and Maloney. Laguna Hills, CA. Design and construction of shipboard waste treatment, air emission control, and biological process plants. Consulting on IMO and Coast Guard Environmental Compliance issues.

Chief Engineer, Gas Control Engineering. Anaheim CA Supervision of engineers in the design of Gas Collection systems, Methane and Hydrocarbon monitoring systems.

Principal Engineer at MPI International Inc. Anaheim, CA. Managed engineering design and construction projects, domestic and international in the Food, Oil, Metal finish, Textile and Chemical industry.

Published works " Chemical Engineering " Periodical.
The American Petroleum Institute,
Purdue University Industrial Waste Seminar Manual.

ADDITIONAL ACHEIVEMENTS:
President Jimmy Carter's Strategic Oil Reserve, Louisiana. Served as consultant in design of oil/brine water separation systems, supervised pilot studies and solids removal plant construction Bellaire LA.

U.S. State Department, Federal Executive Service Corp : Review environmental conditions, Belize, . Advised the Natural Resources \ Tourism Ministries on several sanitary engineering projects including: Recommendations to remediate the polluted canals and groundwater of Belize City, Advised on the design on the Blue Lagoon Bottling Water plant, recommended water reuse programs on Amberiges Caye

US AID contract: . Assist City of San Salvador, El Salvador on industrial environmental issues.

Dept. Business Development, Office of the Governor of Alabama: Engineering economic study on design, construction, and operation “Private Sector Owned Cluster TSD Facility” for Loundes County. Prepared similar studies and recommendations for the cities of Oroville CA and Adelanto CA.

U.S. Coast Guard: Redesigned extended aeration systems aboard 10 Tankers and Cruise liners.

Baja California, Mexico: State Health Dept. Study “ Remediate Lead in Groundwater and Soil Contamination at Tecate” that had affected local dairies and threatened the health of neighboring communities. Received a letter of commendation from the Honorable C. Ruffo, Governor, in recognition of technical input.

NOTEWORTHY RELATED EXPERIENCE .

Pressure vessels design- steel & alloy
Pump, Valve, & Filter systems
Vacuum collection systems
MCC & Electrical design & installation
Linings/coatings selection-application
Electrical wiring and panel design
Fans and blower systems
Instrumentation design from P&ID
Material selection - corrosive environments
Air scrubbers and stripper systems
Piping systems steel, alloy, non-metallic system design
Autoclave and boiler design
Clean room environment design

Project management: Interface with clients, attorneys, inspectors, and technical experts.

OTHER SKILLS:

- Autocad 13 and 14, Word, Wordperfect, MSOffice, Spreadsheet & Data Base Programs.
- Accounting system software.
- Process control system programing

AGENCY INTERFACING:

- AQMD rules and compliance requirements
- Local Sanitation Districts and their regulations
- Various City Bldg & Safety requirements
- State Water Resource Board requirements
- Federal EPA rules and forms
- OSHA field construction regulations

ABSTRACT

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ENGINEERS AND CONSTRUCTORS

"Redesigning and Refurbishing Noncompliant Shipboard Treatment Plants"

Recently the U.S. Coast Guard and the IMO moved to strengthen shipboard black and gray water discharge regulations. Efforts, so far, focus on the Cruise Line industry that traverses inland passageways, for example Alaska. Not surprising, to us, is the fact that most ships are currently out of compliance.

These events have triggered the interest of many equipment manufacturers, some experienced in shipboard treatment, and all eager to introduce their latest treatment concepts to the fleet at a significant cost to implement. This paper touches, briefly, on our experience with some of these innovations.

The principal topic covers ships with packaged treatment plants already onboard and the state of these plants from a design and operations viewpoint. Some ships have three or four separate systems each and
about 95% utilize some form of activated sludge biological treatment method. Therefore, it is prudent, technically and financially, to exhaust all efforts to optimize these systems rather than accommodate space for new, untried, methods.

We look at the serious design problems with the existing plants. Methods are available by which these plants can be modified, improved and brought into compliance, including those that are considered very problematic. Attention must also be focused on ship crew training in an effort to improve operation practices. We emphasize that most of these treatment problems can be alleviated

The vacuum collection system is ancillary to the black water treatment but it too introduces problems that must be addressed. We examine some methods in the treatment of gray water. It is more voluminous, and requires different problem solving techniques.

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REDESIGNING AND REVURBISHING EXISTING SHIPBOARD TREATMENT PLANTS TO COMPLY WITH CURRENT REGULATIONS

Ask any chief engineer what problem areas within the ship are the most perplexing. Don't be surprised if engine performance and equipment maintenance is not at the top of his list. There are very few biological treatment plants producing effluent discharges that are within the U.S. Coast Guard and IMO regulatory limits.

As you know, land based plants experience a myriad of process problems but none are quite as complex as those aboard ships. One major distinction is that you can see everything in the former. Usually 20 centimeter diameter, plastic, view ports provide little insight into what is going on in the reactor tank.

Also, most land based plants have volumes of data and sampling results for immediate and historical evaluation whenever problems arrive. Often they are precursors that can head off problems before they arrive. Not so with ships. It took about two years for us to develop basic, vital, per capita information that would be basic to any elementary pre-design conference. Even today, we notice that there is a dearth of waste characteristic data available from most of the ships we work aboard.

As a matter of fact, we have forbidden anyone in our company from asking the question " I wonder what the original equipment manufacturer was thinking when he built this plant" That shall remain, forever, one of the worlds unanswerable queries.

This paper addresses some very important elementary questions:

- What to do when the plant is out of control.
- Step to take to get it back into the control.
- How modify the plant as needed.
- How to keep the plant in control.
- How to ensure the regulatory agencies that the plant is secure, and operating properly.

TOPIC LIMITATIONS

The paper focuses, principally, on biological treatment techniques, the most predominant and the most problematic of today's cruise ship fleet. They have been for many years. Our scope is narrowed even further to the Activated Sludge Treatment (AST) methodologies. With few exceptions, this has been the process of choice among treatment plant manufacturers.

We touch on these exceptions, the alternate treatment methods. We hold the opinion that they too have been exposed to the same misinformation and specification; consequently, we expect they will be equally problematic in the future. Most of these have not as yet warranted the same attention. We anticipate an increased interest in whatever corrective measures are available to meet these.

Our intention is not to cast disparaging remarks about the treatment plant designers and manufacturers. We concluded, years ago, that much misinformation was floated about concerning this highly concentrated wastewater , its characteristics and even its volumetric flow. Our intention is to address the problems and emphasized the specific steps to remediate these problems.

Finally, this paper reflects the mandate given us by the various ship owners. That is to do all that is possible to fix the problems. The caveat is that we must confine the solution, if at all possible, to utilize whatever facility is in place aboard the ship. Not to venture out to embrace the very jagged and expensive edge of science. That has proven to be a prudent mandate, financially, operationally and expeditiously.

REDESIGNING AND REVURBISHING

FUNDAMENTALS – BRIEFLY

Dire consequences await any design engineer who fails to reconcile the significant operational differences between ship board and land based treatment plants. Unit flow rates to the latter are 29 times greater but the strength characteristics are1/12 of the ship's waste. A Shipboard plant process only black water while grey, black, and industrial wastewater is handles on shore. Operations personnel prefer mechanical related issues to those generated by sewage sources. However, to understand the context of this paper you need to have at least a fundamental knowledge of what is taking place on Deck 1.

Black water entering any sewage plant (refer to Fig 1) is mostly waste products from a residence or from people places. Land based plants handle grey water (kitchens, baths, and showers) and black water.
Ship board plants are called upon to treat only toilet and urinal discharges, 95% of which are organic, biologically degradable. That waste is a food source for thriving colonies of microorganisms already living and reproducing in the treatment plant**.** ***Waste Strength*** is an engineering that indicates the voracity by which a food source tends to extract the oxygen that is normally dissolved in water. It forms the basis for selection of various, ultimate treatment techniques. This ***Dissolved Oxygen(D.O.)*** reading is a component in the equation to determining the ***Biochemical Oxygen Demand, (BOD)*** expressed in milligrams per liter.

Organisms that assimilate the food are living species, bacteria etc., the ***Mixed Liquor Suspended Solids (MLSS)***. We have learned, through microscopic observation, that most are beneficial to treatment, some are detrimental. We know the successful treatment requires a balance, a relationship, between:
The weight of the food ***(BOD)*** to that of the bioculture ***(MLSS)*** is referred to as ***(F:M)*** ratio
The time the food source solids are exposed to bio-colonies, the ***Solids Retention Time (SRT)***.
The most effective weight of ***MLSS*** that can be supported in a cu. m. of aeration reactor.

In addition to the waste solids, other compounds enter the mix to assure a healthy bioculture in the reactor, the most important**-** ***Oxygen*** in order for the reaction proceeds to it final product of CO2 and water.

- Recall, the food waste demands it,
- The organisms require it to assimilate food to meet the needs of their individual cell growth,
- The reproductive driving forces require it,
- The respiration, the destruction and re-growth of new cells requires it.

The most available source aboard a ship is the air blower. Unfortunately, the transfer of oxygen from the air to the water determines its effectiveness. On shipboard plants it takes 200 cu m of air to transfer a kg or less oxygen into the water. As you can see, one must design the aeration system very carefully in order to achieve the best transfer.

The final treatment step is to separate the MLSS and return these microorganisms to the raw waste inlet so they can commence the digestion process all over again. The ***Return Activated Sludge (RAS)*** We now introduce another series of variables into process equations.

- The quantity of RAS per day is tied to the desired efficiency of BOD removal.
- The frequency of its return, the recycle rate, is another factor, and
- The concentration of the RAS depends on the efficiency at which the MLSS settles out,
- The system must make room for new growth organisms so some of the RAS must be wasted or discharged overboard at the appropriate time and within the legal boundaries. The ***Waste Activated Sludge (WAS).*** The determination of these quantities is empirical and dependent upon operator training and knowledge.

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Further complexities enter into the equation once we conduct a search of current literature and periodicals. There are volumes of research and technical papers available on the characteristics of shore based waste. Searches into available ship board operations produces essentially no data and finally, the there is a limit on the usefulness of the data we glean from these works.

REDESIGNING AND REVURBISHING

Heretofore, the treatment of sanitary wastewater falls in the realm of the civil and sanitary engineering disciplines where volumes of published works on this subject are available. The waste characteristics are so consistent that most plant designs are, all too often, sort of handbook procedures. Industrial waste discharges , of course, are always a challenge.

Consequently, most engineers regularly engaged in the treatment of industrial waste are accustomed to large variations in waste characteristic, for example, BOD loading greater than 20,000 mgl and high influent temperatures. As a result, we felt competent in addressing marine wastewater problems.

DEPARTURES FROM THE NORM

We discussed previously the strength of a ship's black water. The ship generated ***grey water***, which is generally not treated, on the other hand, is very similar to that found shore based plants. Proposed regulations are being formulated as we speak and will likely be addressed by various authority agencies shortly.

We became aware, quickly, that shipboard treatment can experience frequent, instantaneous, upsets because of the shock loads that carry sludge particulate with very high anaerobic content because of the retention time in the collection tank and associated piping . In addition, temperature changes come often and they can reach levels well above the ceiling prescribed for most appropriate organisms needed for waste assimilation.

Infiltration of cleaning chemicals utilized by the hotel people is inevitable and must be carefully monitored and controlled with the ultimate concern for the biological population in the treatment tanks. The paper discusses the use of certain biodegradable and biologically enhancement products.

DESIGN PARAMETERS

We still rely heavily on developments emanating from shore facility. Most data is very useful and applicable to shipboard plants. We refer particularly, to various "Methods of Operation" and research publications offered by professional organizations such as the WEF. There is, however, a point of departure for packaged treatment plants similar to those aboard ships. There, performance conditions take us into unfamiliar territory. For example,

- The limits on the concentrations of ***RAS (Return Activated Sludge).*** You must be cognizant of the quantity of microorganisms that can physically occupy a 10 cu m treatment reactor.

- There are very important lessons to be learned from the wasting activated sludge ***(WAS***) techniques.

The selection of these shipboard plants, from the outset, seems to have undergone an identity crisis. Do we have ***a "Conventional"*** (AST) plant or is it an ***" Extended Aeration " (EA)*** plant? Operational criteria is quite different and especially the BOD loading per unit volume.

Refer to table 1. We have taken the liberty of using the manufacturers published results of the IMO 1979 certified test data***. Refer to Agency Notification below***. Note that the removal efficiency and the BOD unit loading for one manufacturer implies that this plant is really an AST design. Whereas the same data for the actual onboard treatment plant looks more like an EA plant. The same is true for ***Hydraulic Retention Time (HRT)*** data.

Conventional activated sludge plants have an HRT of 8 hours. BOD and TSS removal efficiencies range from 87% to 90%. These are significantly less than some of the other activated sludge methods.

Extended aeration plants have an HRT of 18 –24 hours. Ideally, designers strive for an operation where all the food has been completely assimilated by that time. The effluent overflowing into the clarifier then consists of only inert solids and microorganisms. BOD and TSS removal efficiencies of 98% are not uncommon .

One actual shipboard installation illustrates the problem succinctly. It certifies an HRT of 29 hrs. It quotes data from an original 1979 test. Our conclusion then is that since its data our EA criteria we elected to use that methodology as our guide in redressing existing shipboard plants.

PROBLEM AREAS – THE TREATMENT PLANTS

After some in depth exposure to 16 ships we completed the following list of significant problem areas. Some can be changed, others completely replaced and we have had to live with others. We list these in capsule form and we discuss each of them in detail later:

1. The reactor tanks are too shallow, mostly about 2 m or less
2 Clarifier HRT, weir rate, surface loading rate and sludge withdrawal mechanisms: inadequate
3 Proper and effective Influent distribution: absent
4 Return Activated Sludge system: Inadequate
5 Waste Activated sludge management system: Doesn't exist in most cases
6 Oxygen Transfer Rate is less than 2% efficient
7 Disinfectant system: Inadequate
8 Raw wastewater transfer system: A detriment to plant operation
9 Blower selection: Regenerative blowers are not suitable for this service because of the are very inefficient and generate too much heat. 100C temperature rise over ambient is commonplace
10 The vacuum systems cause as many problems as the poorly designed treatment plants.
11 Potentially dangerous practice of storing bio sludge in double bottom tanks

OTHER PROBLEM AREAS – THE SHIPS CREW

Our effort to bring the ships into compliance started in the early 90's. Typically, one or two senior engineers, very capable ship designers and/or operating engineers would be assigned to the project. We would endeavor to describe the process, the equipment needs, and the areas to monitor. We suspected that once we left the ship their regular duties took priority and the ship reverted back to a transporter, legally, of raw waste water as they headed for the twelve mile limit.

Almost no ships have any analytical test equipment on board. Instrumentation such as pH and ORP monitors were essentially unknown to the crew. Some ships had a few beakers, perhaps an Imhoff cone, and one or two graduated cylinders. There was never a microscope to be found. We saw only a smattering of sample ports on the reactor (Aeration Tank), no pressure gages anywhere, no temperature gages, and a very few sight glasses or viable sight ports.

Shore based facilities understand the need for all of this. If you can detect a negative trend in the plant performance before it inundates the entire system then all of this is worthwhile. A microscope, for example, can indicate what organisms are prevalent or are about to be prevalent. That allows sufficient reaction time to meet the problem early.

Until recently, we were merely engineers and contractors aboard the ship. Currently, we have recently been forced into process management and biological and chemical monitoring.
Shipboard Plant

AGENCY NOTIFICATION

All MSD plants carry a certification based upon specific, prototype design and similarity design, as well as a performance warranty statement. Further, the IMO and the USCG require that any changes to this design must be clearly noted and re-certification is required and perhaps additional performance re-testing.

REDESIGNING AND REVURBISHING

1 REACTOR DESIGN

Flow into the reactor is made up of two elements, the raw waste water and the microorganism component in the sludge drawn, continuously, from the bottom of the sedimentation tank, the RAS. Usually, this recycle is 50% to 150% of the raw waste water flow.

When the USCG discharge criteria (150 mgl) and the influent TSS (1400 mgl) are inserted into the equation one determines that better than 90% removal is a minimum requirement. Since much of the TSS

is colloidal the designer needs to set 95 to 98% as a design objective. The latter criteria falls within EA methodology and not the "conventional".

For example, a 22 cu m plant would be effective treating less than 24,000L/day black water flow.

2 CLARIFIER/SEDIMENTATION TANK

Process engineers have written volumes on the design of solid/liquid separation theory and design. Most plants we have observed show that insufficient attention is paid to designing the weir and the hopper bottom.

Hydraulic retention times (HRT) should be greater than 3 hours and steady state conditions should be the ultimate goal of the designer.

Overflow rates, the actual hydraulic loading, should be less than 20 cu m /day for each sq m of clarifier surface area. This allows a settling velocity, what we call the "terminal velocity" of 6 –7 cm/min.

3 CLARIFIER INTERNAL DISTRIBUTION AND COLLECTION

The settleable solids concentration is very high and hindered settling zones develop very quickly. Since these can be readily "re-slurried" there is a need to distribute incoming flows to avoid unnecessary eddy currents that will hinder settling.

Weir rates will determine if there is excessive turbulence in the overflow into the clarifier. Anything in excess of 1250 L/min per cm of weir length should be avoided.

4 RETURN ACTIVATED SLUDGE

Refer to example 1. Note, the weight of microorganisms is 140 Kg/day. Assume the Hydraulic Retention Time, in the aeration reactor, is 24 hours. Then the weight of RAS to be recycled is 140 Kg/d. Further, if the highest solids concentration (bottom of the clarifier) is say 1%, the weight of return slurry will be 14,000 Kg or 14 cu m/day. Combine this with the raw water influent flow of 18 cu m/day. The reactor volume, then, must be 32 cu m to achieve effective treatment.

5 WASTING SLUDGE

A rule of thumb starting point is to assume the microorganism population increases at the rate of 15% of the BOD. This will increase the bio-colony through the formation of new cells. Therefore, it follows that you must waste this weight equivalent. Example 1 indicates that 28 Kg BOD will be processed per day. Then 4 –5 Kg of the sludge in the clarifier bottom must be sent to the waste tank for discharge from the ship. Since this is at 1% also the total volume for discharge is 400 L/day. This sludge should be held in a separate thickener for discharge later at the appropriate and legal location.

6 OXYGEN TRANSFER EFFICIENCY

Refer to Table 2. As you can see, the water depth plays a significant role in the amount of oxygen that can be dissolved into the wastewater. These shipboard treatment plants are too shallow and consequently the effectiveness of transfer will be 1 –2 kg of O_2 per 100 kg supplied. That places a demand on the size of the blower.

REDESIGNING AND REVURBISHING

7 DISINFECTANT SYSTEM

Shore based plants have taught us valuable lessons in this area. Two important factors in effective disinfectant usage are time and mixing. Chemical disinfectants such as bromine, fluorine, peroxide, permanganate, and various chlorine compounds are common.

Land based raw sewage, for example, requires almost 25 mgl chlorine dosage and untreated ship sewerage 10 to 15 times that. About 30 minutes contact time is required for an efficient kill ratio. This is not a recommendation to treat raw sewage.

Most require at least an acknowledgment of pH adjustments. Combined and free chlorine remaining in the water after a specific time is referred to as the chlorine residual. Testing should occur immediately after the solution is applied to the effluent holding tank. A pH 6.5 – 7.5 is ideal because it forms Hypochlorous acid (HOCl) , the most effective form of free chlorine. The objective is to discourages the formation of Hypochlorite ions (OCl-) a less effective disinfectant.

8 RAW WATER TRANSFER METHODS

Wastewater process' achieve highest efficiencies whenever there is steady state incoming flow. Equalization is best achieved using upstream tank capacity. That's a positive feature on ships employing vacuum systems. They are usually arranged so that cabin discharges report to a receiver holding tank, approximately 10 cu. m capacity.

A raw water pump transfers a predetermined level of water to the treatment reactor. The combination of instantaneous transfer and a high strength waste has a negative implication, a shock load. The microorganism population is stressed when exposed to these conditions and the result can have a serious effect on treatment.

There are other problems associated with extended solids retention time. For example, vacuum systems that hold solid waste in the piping system for several hours are problematic. It is not unusual for solid material to be held for several hours.

Whenever tank level controls are set more than 1.0 m (5.4 cu m) apart one can expect the hydraulic retention time in the 10 cu m receiver tank can reach 12 hours. Under these circumstances anaerobic conditions are likely and especially formation of troublesome, actinomycetes, foaming and poor efficiencies.

9 BLOWER

Most MSD plants we have seen employ Regenerative blowers. They are much less expensive and much less efficient than other types. For example

BLOWER TYPE	ADIABATIC(a) EFFICIENCY	TEMP. RISE(b) (over ambient) C	DISCH (c) TEMP C
Regenerative blowers	30%	90	80
Positive displacement	60%	32	64
Rotary vane blowers	55%	37	69
Centrifugal blowers.	50%	35	67

a. Manufactures curve data
b. True 100% adiabatic compression states a temperature rise of 59 C per Kg./sq cm compression.
c. Actual measured air temperatures at 0.25 Kg/sq cm discharge pressure assuming 30C ambient.

REDESIGNING AND REVURBISHING

The Alaskan ambient temperatures help to keep the overall process tank temperatures in check. However, Caribbean cruises can raise the We have noted MSD temperatures as high as 47C on Caribbean cruises. As indicated, the particular microorganisms of interest to us cease the growth phase at about 37C and life is usually not sustainable at 45C. This means that treatment has stopped and the MSD is now a storage tank for raw sewage.

10. COLLECTION SYSTEM – VACUUM

Most ship board piping systems we've encountered draw wastewater from a receiver tank and circulate it through an eductor in order to maintain constant vacuum in the piping coming from each cabin water closet. This system generates heat energy as a function of the pump characteristics. Discharge temperatures rise due to inherent restrictions introduced through the eductor. Temperatures of 30 –40C downstream of the eductor are not uncommon. Often the consequences of adding this heat energy to that of the blower heat of compression will force the MSD to operate in a bacteriological kill range.

For example, consider the hold time of sewerage in a piping system using the following assumptions:

Number of toilet drain lines to each MSD	11
Diameter of horizontal line	10 cm
Approximate length of one horizontal run	30 m
No toilets on each run	40
Estimated daily flow per line	1800 L
Volume of half full pipe 10 m long	150 L
Estimated Retention Time in piping system	2.0 hr

BLACKWATER HOLDING TANK: The volume of this tank is about 10 cu m. and the operating volume (between level sensors) is about 4.5 cu m. A daily influent, typically 18,000 L means an additional 6-9 hrs hydraulic retention time and in some cases even longer over low flow periods.

Since this holding times greater than 6 –7 hours under anoxic conditions tends to encourage the growth of certain undesireable miocroorganisms, ie: ***Nocardia*** that have serious consequences:

- Their rapid growth will retard the aeration process in a confined reactor tank,
- They form biological filaments conducive to very serious scum formations,
- They tend to overwhelm the aeration tank.
- It is not uncommon for them to blind off a clarifier overflow system,
- The rapid reproduction rate generates large quantities of sludge

Control of microorganism growth and sludge holding times in all tanks is essential. The ship's MSD plant operator must calculate these parameters at least once a week.

Shore based plants withdraw the clarifier sludge to a thickening tank prior to discharging for further to an anaerobic treatment. Generally this results The further degradation of the sludge , when mixed with primary sludge is a potential force for manufacturing methane, carbon dioxide and more than often hydrogen sulfide.
Primary sludge are very similar in characteristics to galley waste and so there is a similarity in process.

Design of shore based digesters allow for the continuous suspension of the sludge and ultimately the settling and removal. The latter accomplished by tanks whose bottoms are specifically designed for sludge collection and removal.

REDESIGNING AND REVURBISHING

11. DOUBLE BOTTOM TANKS

Storage of waste activated sludge and primary treatment solids is an important part of the shore based treatment scheme. The process is anaerobic in nature and is carried out in a digester. There, acid former microorganisms and methanogens intercept the food batch and begin to produce organic acids, methane, and all too often, hydrogen sulfide gas. The digesters are constructed so that they are:

- Isolated from any atmospheric oxygen,
- Confined space that is generally dark, and
- Significant mixing allows the gas to escape. tatic.flow conditions exist.

Note that almost the same conditions that exist in a double bottom tank except that the flow is generally static and the sludge is allowed to settle on the bottom and ferment. In addition, the slope and configuration of double bottom tanks is conducive to anaerobic solid accumulation. This is potentially a dangerous process aboard a ship..

12. MONITORING

We have encountered a lot of indifference from the crew on this subject. We can only assume this arises out of the need to familiarize oneself only with the function of mechanical equipment in the engine rooms. Listed below are the important items and frequency that require attention:

PROCESS PARAMETER	TEST FOR	FREQUENCY OF OF TESTING	MINIMUM TYPE OF TEST EQUIP	TIME REQ"D TO PERFORM
D.O.	OXYGEN(dissolved)	daily	D.O. meter	10 minutes
TEMP	Temperature	daily	Gage mounted on reactor	1 minute
TSS	Suspended solids	weekly	microfilter Vacuum pump 150C oven or heat source Scale	1 hour
BOD	Biochemical Oxygen Demand	monthly	A dark room @ 20C BOD Bottles D.O. meter	15 minutes
Coliform	Pathogenic Organisms	monthly	MPN vials	30 minutes
SVI	Sludge Volume index	weekly	Cone test tube	35 minutes
Sludge	Settled sludge test	weekly	Cylinder 1L	30 minutes

TROUBLESHOOTING

Listed below are several techniques that we use to determine the origin of operating problems. Ship board plants, of course, introduce an additional complication – they are usually without access during operations.

INDICATOR	**PROBABLE CAUSE**	**POSSIBLE SOLUTION**
Floating sludge	Filamentous Organisms Nocardia	SVI is < 100 Increase DO if < 1.5 Microscopic exam Increase the RAS Increase the MCRT to > 6 days Add 5 – 10 mgl Chlorine to RAS

Gasn Final Clarifier	Nitrogen gas attached to sludge particles	Increase pH to 7.0 Increase RAS Increase WAS

REDESIGNING AND REVURBISHING

Troubleshooting continued

INDICATOR	**PROBABLE CAUSE**	**POSSIBLE SOLUTION**
Pinpoint floc in clarifier	Excess turbulence in aerator	Reduce aeration rate
Turbid effluent	Anaerobic conditions in aeration tank	Increase WAS and DO
Dark Tan foam	MCRT too long	Decrease MCRT to < 9 days
Aerator content too dark	Inadequate aeration	Increase air or decrease load
Sludge overflow into clarifier	Poor flow distribution in aerator	Level the weir or redesign the aerator outlet weir
Air rises in very large bubbles	Diffusers broken or plugged	Replace
pH <6.7	Nitrification occurring	Decrease sludge age Increase WAS

TABLE 1

AERATION TANK	F:M RATIO Kg/Kg	BOD LOAD Kg/cu	HRT Hr	Max Design Concentration mgl BOD	Removal % BOD
Conventional AST	0.50	0.96	8	250	90+
EA Plant	0.15	0.25	24	250	95
Manufacturers Certified test Data *	NA	0.92	NA	384	87
. Onboard plant actual certified performance statement by a Mfg**	NA	0.9	29	1,080	95.3

Comment: The BOD load implies that the shipboard plant is of the AST design.
The hydraulic retention time (HRT) figure and the efficiency of BOD removal implies an EA plant criteria
The prototype MSD 2 model was tested, in 1979, on influent loads of 380 mgl
The latest plant implies it can handle 1,080 mgl
Onboard sampling indicates the load is about 1,500 mgl

* IMO Resolution MEPC.2 (12) Regs 5(1) (d) (L) Annex IV Marpol 72/75 completed in 1979
40 sample tested . Apparently on shore based concentrations.
** Date lifted from one manufacturers final certification documents

THE AUTHOR

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Education:
B.S. Mechanical Engineering McGill University (Chem. E. optional year program)
M.S. Civil Postgraduate studies: Purdue University Industry/experimental sponsored program*.
Business B.Commerce George Williams College, Concordia University
Diploma U.C. Redlands Soil Remediation and UST Design and Removal
Lecturer UCLA Extension -Downtown Environmental Engineering Course.
Lectured in "The Treatment Techniques used in Industry and POTW's"
***** Program interrupted military service resumed in 69

LICENSES
Registered Professional Engineer : California, Arizona, British Columbia, and Quebec.
California State Contractors Board : "A" General Engineering Contractor, "B" General Building Contractor, Registered Cal-EPA Class A Environmental Assessor
California State License: "ASB" Asbestos Removal, and "HAZ" Hazardous Materials Removal

Engineer – chief, Benchmark Inc. Anaheim, CA. Directed engineering group in the design and construction of wastewater process plants in the Oil, Chemical, and Food industry.
Senior Engineering Field Manager for installation of wastewater plants within the Electronics Industry.

Director of Engineering, Ramsey, Nickerson, and Maloney. Laguna Hills, CA. Design and construction of shipboard wastetreatment, air emission control, and biological process plants. Consulting on IMO and Coast Guard Environmental Compliance issues.

Chief Engineer, Gas Control Engineering. Anaheim CA Supervision of engineers in the design of Gas Collection systems, Methane and Hydrocarbon monitoring systems.

Principal Engineer at MPI International Inc. Anaheim, CA. Managed engineering design and construction projects, domestic and international in the Food, Oil, Metal finish, Textile and Chemical industry.

Published works " Chemical Engineering " Periodical.
The American Petroleum Institute,
Purdue University Industrial Waste Seminar Manual.

Mr. Maloney served on several civil works efforts in third world countries:

- President Jimmy Carter's Strategic Oil Reserve, Louisiana. Served as consultant in design of oil/brine water separation systems, supervised pilot studies and solids removal plant construction Bellaire LA.
- U.S. State Department, Federal Executive Service Corp : Review environmental conditions, Belize, Advised the Natural Resources \ Tourism Ministries on several sanitary engineering projects including: Recommendations to remediate the polluted canals and groundwater of Belize City, Advised on the design on the Blue Lagoon Bottling Water plant, and water reuse programs on Amberiges Caye
- US AID contract: . Assist City of San Salvador, El Salvador on industrial environmental issues.

- Served as technical adviser Republican National Committee on the environment under President Reagan.
- Dept. Business Development, Office of the Governor of Alabama: Engineering economic study on design, construction, and operation “Private Sector Owned Cluster TSD Facility” for Loundes County.
- Prepared similar studies and recommendations for the cities of Oroville CA and Adelanto CA.
- U.S. Coast Guard: Redesigned extended aeration systems aboard 10 Tankers and Cruise liners.
- Baja California, Mexico: State Health Dept. Study “ Remediate Lead in Groundwater and Soil Contamination at Tecate” that had affected local dairies and threatened the health of neighboring communities. Received a letter of commendation from the Honorable C. Ruffo, Governor, in recognition of technical input.

CURRICULUM VITAE

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Abstract

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"Membrane Bioreactors for Treating Black, Grey and Bilge Water on Shore and off Shore"

Due to increasing discharge standards for liquid wastes from ships, platforms and harbours new treatment technologies have been developed. Recently membrane bioreactors and membrane filtration have been applied treating off shore wastewater streams. Due to the unique combination of biotechnology and membrane technology the membrane bioreactor is a very compact treatment system, which can handle difficult degradable wastewater and has an excellent effluent quality. Some applications of membrane bioreactors are the treatment of black and grey wastewater on ships, the treatment of wastewater on oilrigs, the treatment of production water on gas platforms and the treatment of bilge water from ships. The presentation will deal with several full scale applications of membrane bioreactors on shore and off shore.

MemTriq®Marine

Marine wastewater system ready for the future

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Contents

- Introduction
- Membrane bioreactor technology
- Results
- Examples
  - On shore bilge water treatment for the Dutch navy
  - Off shore wastewater treatment on an oil rig in the Caspian sea
  - On board wastewater treatment
- Developments and challenges
- Conclusions

Introduction

- Helsinki Commission (HELCOM)
  - Wastewater discharge from ships have a serious environmental impact:
    - Baltic sea:
      - 70 million passengers per year
      - 13 million p.e. of wastewater are discharged untreated

Triqua

Discharge standards

- Discharge of wastewater from ships
  - MARPOL Protokoll TSSPP 73/78
    - Faecale coliform < 250 c.c./100 ml
    - Suspended solids < 100 mg/l
    - BOD_5 < 50 mg/l
- New more severe discharge standards
- Specific (severe) regional standards (Miami Dade)

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Existing wastewater treatment systems

- Physico chemical units
  - do often not comply with the regulations
  - addition of chemicals
  - often not allowed any more
- Membrane systems
  - waste concentration
  - operational difficulties (membrane fouling)
- Conventional biological systems
  - do seldom comply with the regulations
  - addition of desinfectants
  - space consuming
  - sensitive for shocks and bumping

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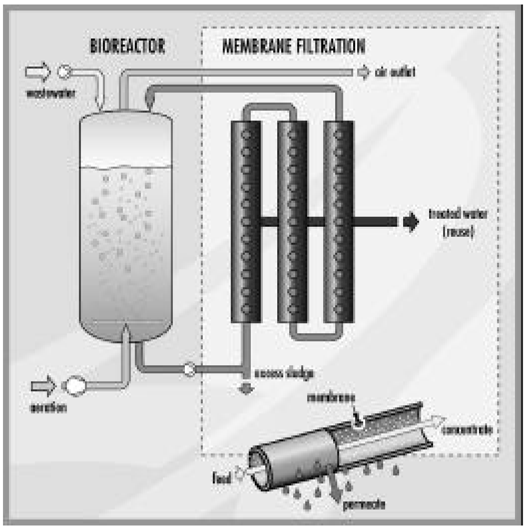
Membrane bioreactor principle



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Characteristics of MBR

- Compact system
  - high biomass concentration (15 - 30 g/l)
  - high degradation rates
  - small bioreactors
  - compact sludge /water separation system

system 5 to 10 times smaller than conventional systems

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Characteristics of MBR

- Little sludge production
  - high temperatures
  - low sludge loadings

experiments have shown domestic wastewater treatment with zero sludge growth

Triqua

Characteristics of MBR

- Specific organisms/optimized bio-process
  - high sludge ages
  - total biomass retention
  - completely controlled environment (pH, T, O_2)

- always nitrification
- degradation of “difficult”compounds
- thermophilic processes

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Characteristics MBR

Reliable process
- never sludge wash out
- completely controlled bio-process
- not sensitive for movements

- application on ships
- application in remote areas

Triqua

Characteristics MBR

- Excellent effluent quality
  - use of micro-/ultrafiltration
    - retention of high molecular molecules
    - retention of all bacteria and most virusses
  - optimized bio-process

- discharge of effluent in surface water
- reuse of effluent as process water

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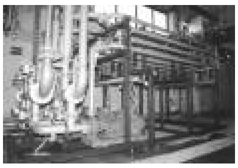
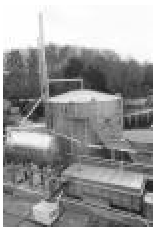
MBR on land

- 10 years of experience
- external and submerged membranes
- domestic wastewater, industrial wastewater
- reuse applications

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Specific advantages for marine applitions

- very compact system
- treatment of difficult degradable wastewater (detergents, bilge water, etc.)
- excellent eflluent quality with possibilities for reuse (technical water)
- stable and reliable process (shocks, vibrations, variation in wastewater flow)

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Treatment possibilities

1. Grey wastewater treatment
2. Black and grey wastewater treatment
3. Effluent reuse

Reuse means technical water: toilet flushing, deck cleaning, window cleaning etc.

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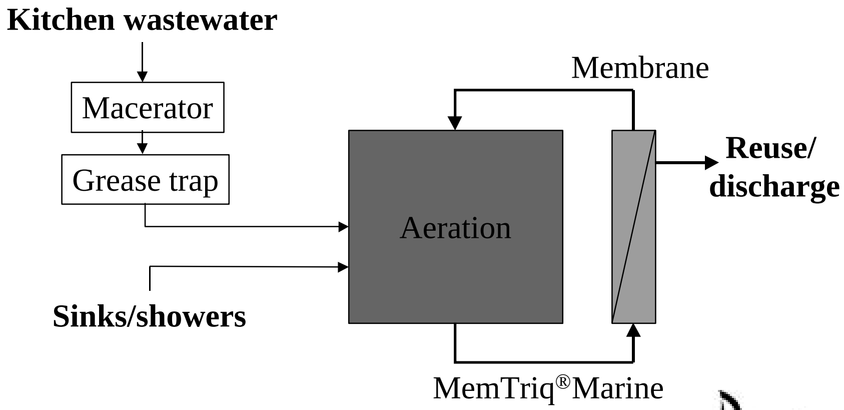
Grey wastewater treatment with reuse



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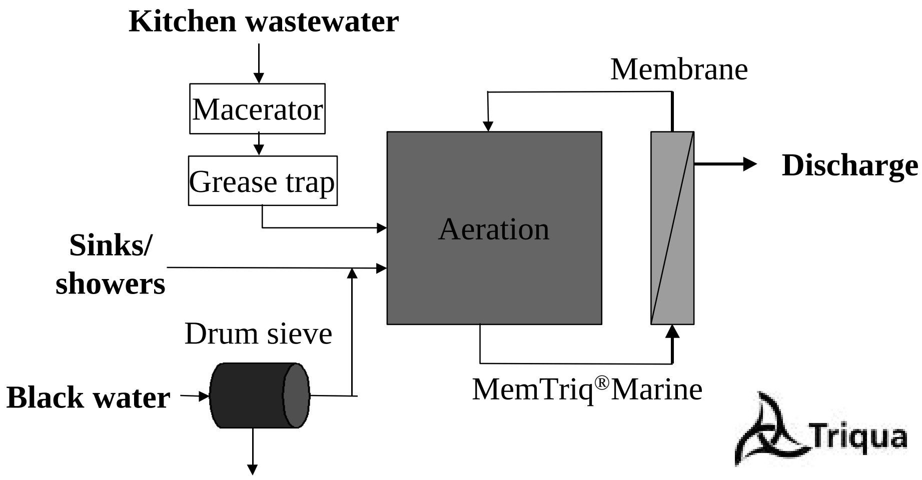
Black and grey wastewater treatment



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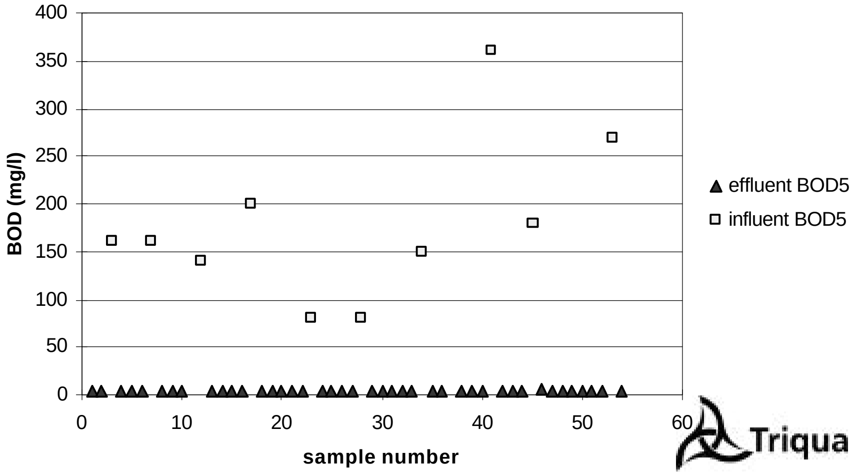
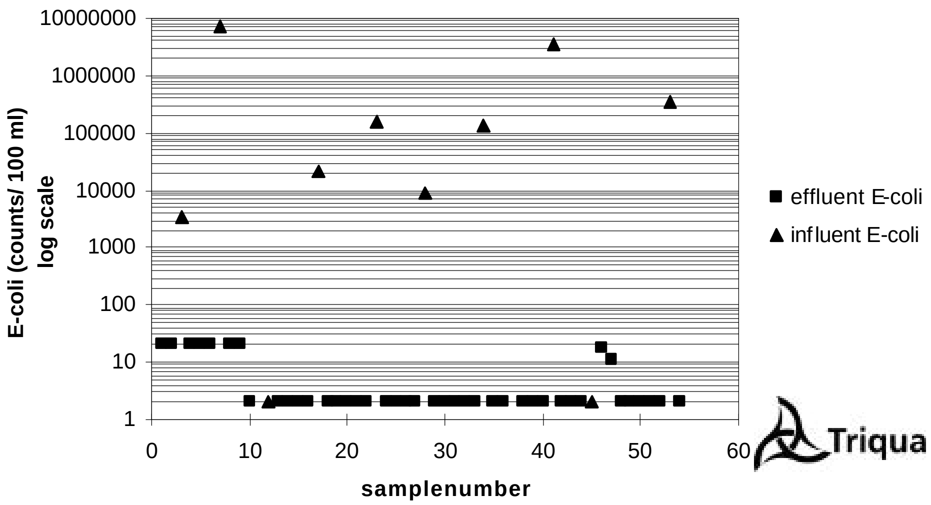
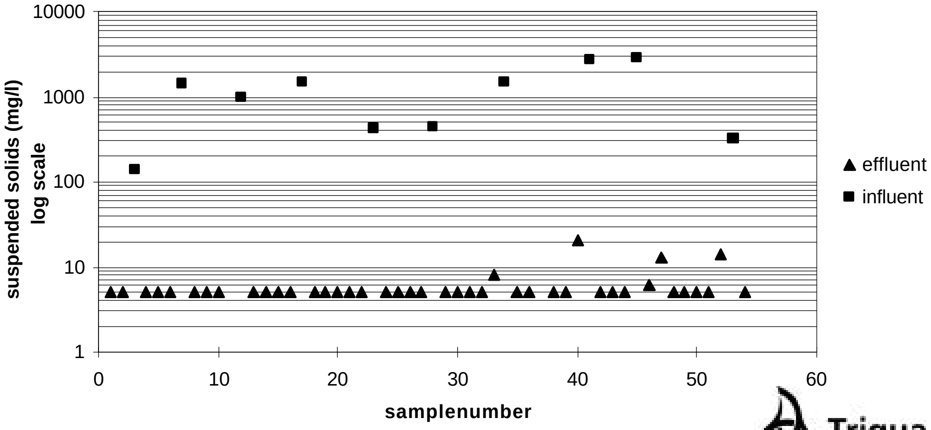
Results BOD_5



Results E-Coli



Results Suspended Solids



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Effluent quality vs Marpol

	Effluent	MARPOL	
Coli	< 2,5	< 250	c.c./100ml
S.S.	< 5,9	< 100	mg/l
BOD_5	< 3,1	< 50	mg/l

Triqua

MBR at Dutch Navy

- Treatment of bilge water from ships
- Bilge water pretreated by flotation
- Discharge of effluent in harbour

	Wastewater	Treated water
Flow (m^3/h)	3	
COD (mg/l)	1.000	< 200
Min. oil (mg/l)	100	< 1
Salt (g/l)	20	20

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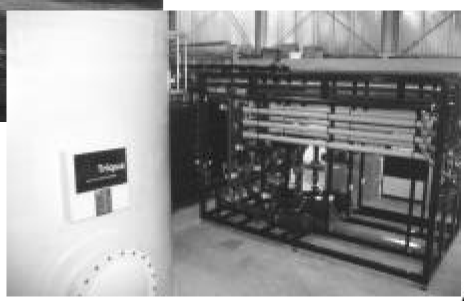
MBR Dutch Navy

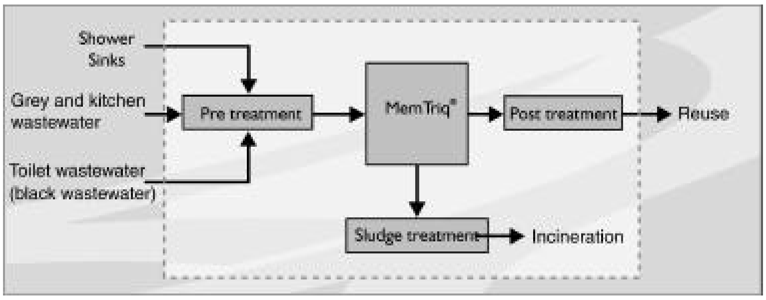


Triqua

OKIOC

- Wastewater treatment for a drilling rig in the Caspian Sea
- Capacity: 120 persons
- Water reuse (tiolet flushing, technical water)
- Sludge handling
- Severe weather conditions (- 40°C till 40°C)

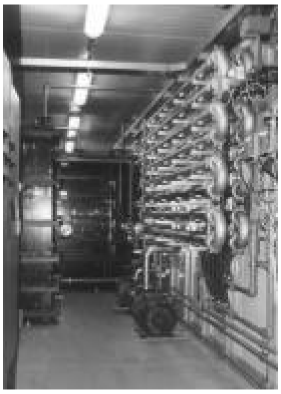
OKIOC proces flow



MemTriq OKIOC

Pre treatment

MemTriq®



Sludge treatment

Triqua

MemTriq® Marine on board

- Supply vessel the Godetia of the Belgium navy
- Capacity: 90 persons
- Treatment of black and grey wastewater
- Nitrification/ denitrification
- In operation: november 2000

- New ship of Greenpeace: the Ecofighter
- Capacity: 60 persons
- Treatment of black and grey wastewater
- In operation: october 2001

Triqua

MemTriq® Marine

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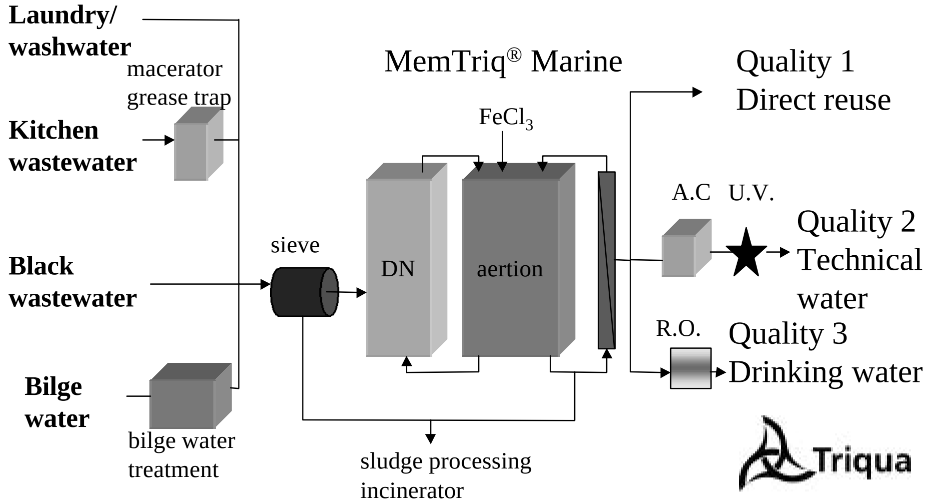
Developments and new challenges

- Compacting bioreactor by use of pure oxygen
- Reduction of surplus sludge and sludge processing on board
- Fargoing treatment and water reuse

Triqua

MemTriq® for the near future



Conclusions

- Existing wastewater treatment systems on board often not comply with the regulations for discharge
- Membrane bioreactor is a compact treatment system with an excellent effluent quality
- MemTriq®Marine is a proven system
- In the near future integrated water systems on board with far going reuse

Triqua

CURRICULUM VITAE

Dr. Rainer Witte, Westfalia Separator Mineraloil Systems, GE

Dr. Witte started his professional career as ships engineer. He then continued his studies at the Technical University Warnemünde and was awarded PhD .
Since 10 years he is with Westfalia Separator company and is acting as Sales Engineer.

The title of the paper is:
State of the Art and Development Trends in Centrifugal Bilge Water Treatment

Abstract

Author: Klaus-Rainer Witte,
Westfalia Separator Mineraloil Systems GmbH, GE

"State of the Art and Development Trends in Centrifugal Bilge Water Treatment"

The treatment of oily waters on board of ships is subject to strict national and international laws and regulations. More stringent observation and partially drastic fines have increased the environmental consciousness of the ship operators.

Nowadays, mainly static oily water separators of different designs are used on board. These separators meet the type-approval requirements of the IMO resolution, but they mostly fail in practical operation when encountering high portions of emulsified oils, ship's movement etc. Consequently, the ship operators are looking for alternatives.

Westfalia Separator Mineraloil Systems GmbH is the first supplier offering self-cleaning centrifuges for this application which are approved according IMO MEPC. 60(33). Centrifuges offer the advantages of very large equivalent settling areas on smallest room, no impact of ship's movement on separation efficiency, continuos separation of oil and water phase and a self-cleaning effect of the disc stack due to total ejection. The centrifugal separation technology is also well known on board.

An intelligent process control adapts the flow rate to the changing feed conditions of the product and ensures that even under worst conditions the system discharges mostly overboard with an oil content lower than 15 ppm and does not run idle in circuit. Mostly there is no need for additional chemicals, however, in case of excessively high emulsion portions, there is the option of adding emulsion breakers. Centrifuges can be very well combined with other equipment and systems which allows high flexibility in operation and adaptation to any particular condition.

Today, there are two centrifuge systems type-approved according to MEPC.60(33), the WSC 5 with a capacity of up to 1,500 l/h and the WSC 25 with a capacity of up to 6,000 l/h. A compact design allows flexible arrangement and easy installation particularly for retrofits. Five years of practical tests on several cruise ships and a compact design have convinced several Cruise and Ferry companies like P&O Cruises, Princess Cruises, P&O Ferries, Carnival Cruise Lines, Costa Crociere and Aida Cruises of the effectiveness of this technique and motivated them to equip or retrofit all their ships.

State of the Art and Development Trends in Centrifugal Bilge Water Treatment

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ABSTRACT

The treatment of oily waters on board of ships is subject to strict national and international laws and regulations. More stringent observation and partially drastic fines have increased the environmental consciousness of the ship operators.

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INTRODUCTION

Centrifuges have been used in shipboard operation for many decades and are regarded as the most efficient solution for the fuel and lube oil treatment on board. More and more centrifuges are used for other applications like sludge treatment and bilge water treatment. There are also trials to use centrifuges also also for grey water treatment. Centrifuges are machines designed for the mechanical separation of liquid mixtures, which is called purification, and of solids from liquids, which is called clarification. Nowadays, self-cleaning, disc-type centrifuges used for fuel and lube treatment are three-phase purifiers/clarifiers.

The particular advantages of centrifuges are:

- Large equivalent clarification area
- No impact of the ship's movement on the separation efficiency
- Easy maintenance and supervision
- Simple process controlling and monitoring

Centrifuges are, however, not able to separate emulsions like emulsified water in lube oil or emulsified oil in bilge water and liquids which are solved in each other like fuel and lube oil mixtures which are indeed solutions.

Since 1996, Westfalia Separator offers two types of self-cleaning, disc type centrifuges also for the bilge water treatment, the WSC 5 and WSC 25. Both centrifuges are core pieces of complete bilge water treatment systems, which are approved according to the IMO resolution MEPC. 60(33).

CENTRIFUGAL BILGE-WATER TREATMENT

The treatment of oily waters on board of ships is subject to strict by national and international laws and regulations. More stringent observation and partially drastic fines have increased the environmental consciousness of the ship operators.

Bilge water is a mixture of:

- Sea-water leakages
- Cooling-water leakages
- Fuel and lube oil leakages
- Waste waters from cleaning processes
- Solids from cleaning processes, e.g. soot from washing of the economisers.
- Drain fluids from settling and service tanks

The bilge water is not a homogenous mixture. It undergoes important fluctuations due to settling effects in the bilge holding tank. The precipitated oil phase hardly differs from sludge. Principally, the solid particles contained in bilge water are bound in the oil phase as well. The water phase very often contains high portions of emulsified oil.

Fig. 1: Particle distribution in product feed

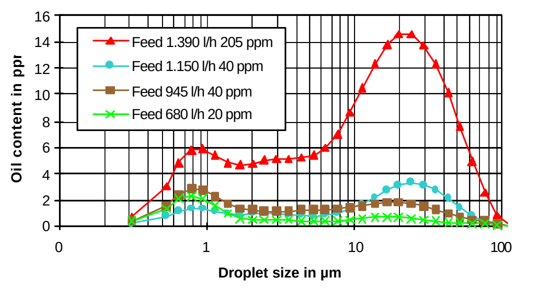


Fig. 1 illustrates analyses carried out on samples taken in a series of measurements within half an hour from the product feed. An approx. 3 weeks' period lay between sampling and analysing. Within this time, the larger oil droplets, tending to separate more easily, had already settled and were not re-mixed into the samples.

These analyses show the limits of a static oil-water separator when treating absolutely normal bilge water, bearing in mind, however, that the dwell time in a static oil-water separator is less than 3 weeks. In addition, they show how rapidly the bilge-water quality can change. Static oil-water separators are most frequently used for the time being. Whereas, under the test-bench conditions prevailing in the type-approval tests according to the current IMO Resolution MEPC. 60(33), they operate perfectly, they fail in most cases when encountering practical conditions involving high portions of emulsified oils.

The separation efficiency of a centrifuge depends on

- the equivalent clarification area of the separator,
- the residence time of the product in the bowl,

- the density difference between oil droplets and water
- and the viscosity of water.

Fig. 2: Density of water and oil

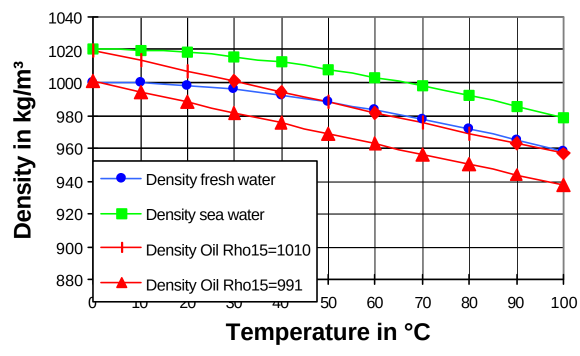
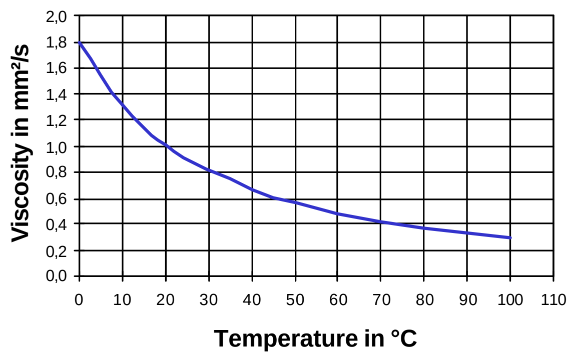


Fig. 3: Viscosiy of water



The density difference between oil and water is enlarged with the temperature while the viscosity of the water is reduced as shown in fig. 2 and 3. The residence time of the product can be influenced with the flow rate. With larger density difference between oil droplets and water, lower viscosity of water and longer dwell time the separation efficiency is improved.

The equivalent clarification area has the includes the most important technical parameter of a centrifuge like bowl speed, number and angle of discs. Due to the high centrifugal acceleration which can reach 7,000 g on the outer radius of the disc, very large equivalent clarification areas can be realised with a centrifuge. The WSC 25 for example, has an equivalent clarification area of 25,000 m². If this settling area were to be realised with a static settling vessel of plate type, the plate insert would require a volume of 50 m³, provided the total height of a plate element, i.e. thickness of plate plus distance between two plates in vertical direction, is just 2 mm.

Fig. 4: Theoretical separation limit of a WSC 5

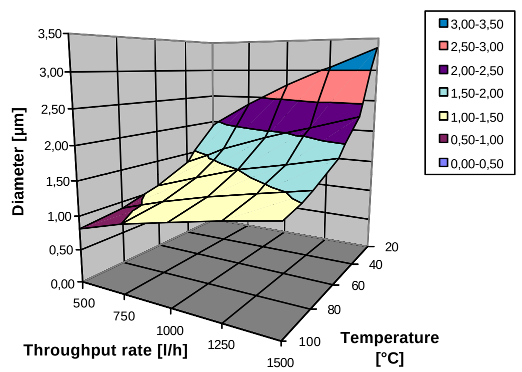


Fig. 4 shows the theoretical separation limit based on equation (3) for a WSC 5 centrifuge at different hourly throughputs and temperatures. For viscosity and density of the carrier liquid, sea-water characteristics, and for the density of the oil droplets, 1.01 kg/l were supposed. The theoretical separation limit of the oil droplets is not affected by the oil viscosity but by the viscosity of water. It is remarkable that the viscosity of the water sinks almost to half its level when the temperature rises from 20 °C to 60 °C, and that the oil having a viscosity of 1.01 kg/l can only be separated from fresh water at temperatures as high as 60°C. Refer to figure 2 and 3. Therefore a separation temperature of more than 60°C is recommended.

In 1996, the WSC 5 with a capacity of 1,500 l/h and the WSC 25 with 6,000 l/h became type-approved. During the subsequent field tests performed on board of MV Victoria, however, it became obvious that considerable differences exist between the type-approval test carried out under test-bench conditions and the normal operating conditions prevailing on board.

Especially the rapid changes in product quality already mentioned caused the oil content in the clean-water discharge to rise often briefly to more than 15 ppm, despite constant throughput rates. Once the oil content had dropped under the 15 ppm limit, a delay period had to be observed before overboard discharge could recommence. This means that, at a constantly high throughput rate, the system often runs idle in circuit, and that practically no overboard discharge takes place. This is why, for the sake of an efficient bilge-water disposal, it is more useful to run the Separator at a lower throughput rate. The most effective solution, however, would be achieved by adapting the throughput rate automatically to the changes in product quality.

THE BILGE-WATER TREATMENT SYSTEM

Figure 5 illustrates the basic concept of a bilge-water treatment system. This system comprises the following main components:

- feed pump
- automatic filter
- pre-heater
- centrifugal separator
- oil monitor
- sludge tank with pump and level control
- controlling and supervisory equipment

Mechanical Separation Division

Westfalia Separator
Mineraloil Systems GmbH

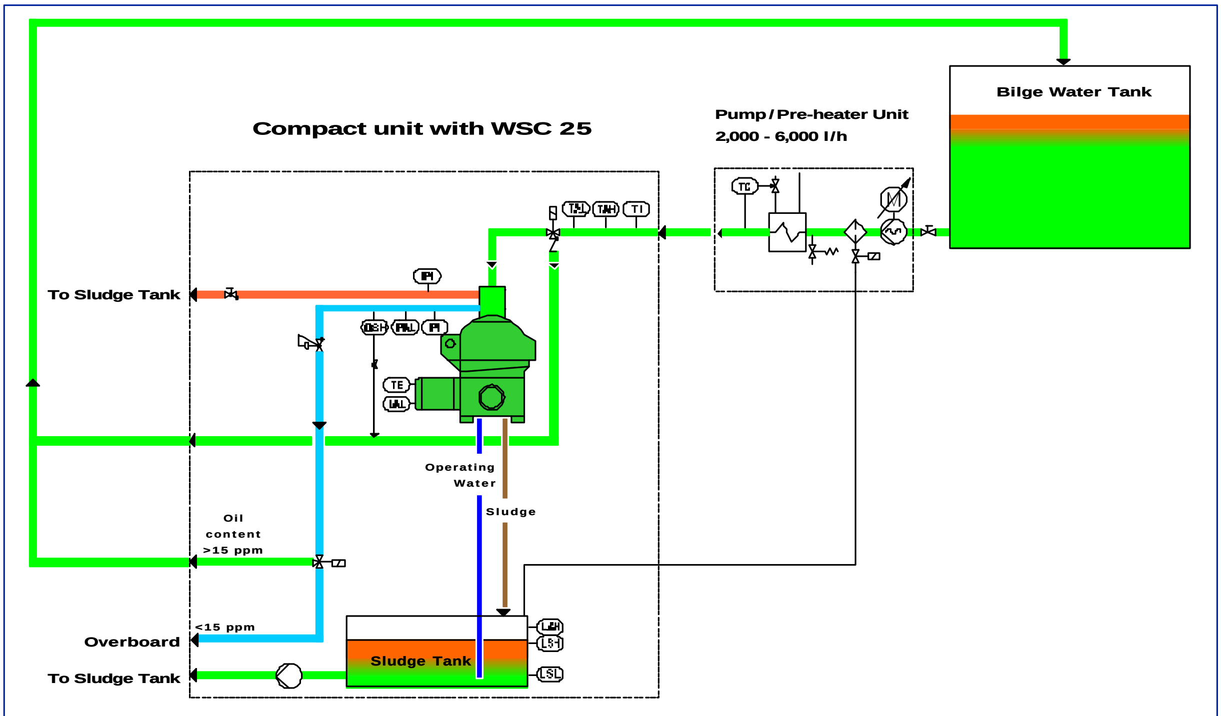


Fig. 5 Bilge water treatment system

The feed pump is a speed-controlled eccentric screw pump. Speed control is effected from the analogue output of the oil monitor via a frequency converter. As soon as the oil content of the discharging clean oil exceeds 13 ppm, the pump is run at minimum speed. When the oil content is lower than 8 ppm, the pump will operate at maximum speed. As long as the oil content lies between these limit values, the control system behaves as a P-regulator.

Behind the pump, an automatic filter is installed. This is a differential-pressure monitored wedge wire filter. It is intended to prevent particles larger than 0.5 mm from entering the separator bowl. The disc stack has an interior rising channel. Since the space between the discs is as narrow as 0.5 mm, coarser particles might clog the disc stack. If the differential pressure switch indicates

In the pre-heater, the product is heated up to separation temperature before being sent to the separator through the feed valve. The bowl is equipped with two centripetal pumps for the light and the heavy phase. Below the centripetal pump for the heavy phase, a regulating ring is installed. In the disc stack, the bilge water is ridded from oil and dirt particles. The oil phase is discharged through the lower centripetal pump towards the sludge tank. The cleaned water is discharged through the upper centripetal pump. A constant-pressure valve ensures a constant counter pressure and, hence, a constant flow rate towards the monitor, even at varying throughputs.

The three way valve in the water discharge is controlled via the oil content of the water. The entire process is supervised by means of a programmable logic control unit and the oil monitor.

The whole system consists of three modules, the pump/pre-heater unit, the compact unit with the separator and the contro unit. The system is very compactly designed. All water-carrying lines and fittings are made of sea water-proof materials.

CONTROL OF THE BILGE-WATER TREATMENT SYSTEM

As already mentioned, an oil-dependent speed control unit of the feed pump adapts the throughput rate of the separator to the varying product conditions. Normally, the separator is fed from a bilge-water or slop tank. In this tank, a preliminary separation process takes place. Conditions are most favourable when the tank is well filled up and sufficient dwell time provided for. The separator will then operate at 80 – 100 % of its optimum capacity, ensuring a residual oil content of less than 10 ppm.

At a decreasing tank level or at higher rates of emulsified product, the throughput capacity will decrease. With the above-mentioned set values of 8 ppm for maximum and 13 ppm for minimum pump throughput, the oil content in the discharging water will level out at 10 – 12 ppm which is clearly below 15 ppm, allowing practically continuous overboard discharge. These settings can be lowered, so that the oil content will always be kept below than 10 ppm or even below 5 ppm. However, this will reduce the capacity of the system. Once the minimum rate, i.e. 40% of the optimum performance, is reached, the oil content can only rise at deteriorating feed conditions, until it finally exceeds 15 ppm, and then the system will run only in circuit.

The length of the period in which the oil exceeds 15 ppm is monitored by the control unit. If this period is longer than 2 minutes, the oil phase is displaced from the bowl or an bowl ejection is carried out. During the pre-set separation time, this procedure can be repeated twice before an alarm is triggered. This is mostly the case if the bilge water tank is almost empty and the upper oil layer is reached.

This condition can also be checked by watching the automatic filter. As already mentioned, the major part of the solids is bound in the oil phase. This is why the time between two automatic cleaning cycles is monitored. If two cleaning cycles are triggered within an adjustable monitoring time, an alarm is signalled as well. This time can be adjusted between one to ten minutes. In this case, the plant should be stopped, and the rest should be pumped off into the sludge tank. It would be useless to treat the settled oil phase in the bilge-water separator, since this phase is anyway sent from the separator into the sludge tank. This would merely give rise to annoying problems such as coking of the pre-heater and soiling of the disc stack.

INSTALLATION AND OPERATION OF THE BILGE-WATER TREATMENT SYSTEM

Mechanical Separation Division

Westfalia Separator
Mineraloil Systems GmbH

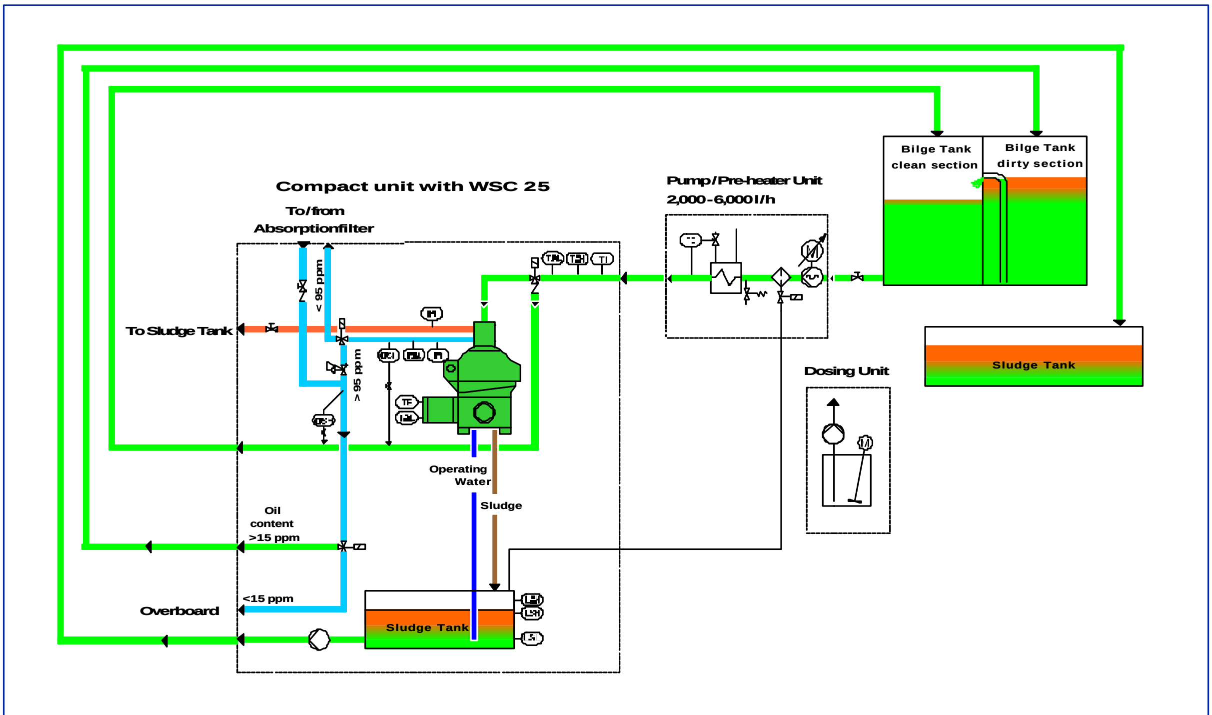


Fig. 6: Bilge water treatment system

Figure 6 shows an example how a centrifugal bilge water separator should be installed in an engine room. The best way to operate a centrifuge is to let it run continuously, i.e. 24 hours per day.

In the harbour the bilge water tank should be filled up completely and separated in circuit. This mode can be selected with a function key on the control. During this time the water will intensively cleaned from all oil and solid particles. If the portion of emulsified oil is too high a special emulsion breaker can be dosed in during this time.

On sea the bilge water tank should be separated overboard. While separating overboard the tank shouldn’t be filled up. Finest oil droplets and emulsions can be removed by an absorption filter installed downstream of the separator. This filter reduces the oil content to less than five ppm.

RÉSUMÉ

Besides the above mentioned general advantages of centrifuges in ship’s operation the particular advantages of centrifuges for bilge water treatment are:

- No impact of the ship’s movement on the separation efficiency

- Continuos separation of oil and water phase
- Self-cleaning effect of disc stack due to total ejection
- Adaptation of the flow rate to the changing product conditions
- Improvement of the separation efficiency by dosing of liquid emulsion breakers possible

A compact design allows flexible arrangement and easy installation particularly for retrofits and new buildings as well. Five years of practical tests on several cruise ships and a compact design have convinced several Cruise and Ferry companies like P&O Cruises, Princess Cruises, Crystal Cruises, P&O Ferries, Carnival Cruise Lines, Costa Crociere and Aida Cruises of the effectiveness of this technique and motivated them to equip or retrofit their ships.

CURRICULUM VITAE

Valentijn Korteling
PROMAC B.V., NL

Mr. Valentijn Korteling after Grammar School got an education as Naval Architect and Mechanical Engineer.
He worked for Van Voorden in a Propeller Hydrodynamics Design Team and on a Controllable Pitch Propeller and Marine Division.
For PROMAC B.V., the company he is presently working for, he was involved in the General Management for 7 years, as a Business Unit Manager for Water Treatment for another 7 years and since 1993 he works on Special Accounts and Business Development again in the field of Water Treatment.
Mr. Korteling will now present the paper on: How to handle the Bilge Water Cocktail

Abstract

Valentijn Korteling
Promac B.V., NL

"How to handle the Bilgewater cocktail"

"Promac Aquacleaner"

is it a never ending story? Or do we have a final solution?

With the new IMO resolution under preparation the definition of bilgewater will be changed in an "emulsified oily water mixture" in stead of oily water.

This definition in fact describes the real on board situation much better and will make all the difference for treatment and monitoring in the near future.

With more stringent regulation for sensitive area's and the satellite infra red detection system in place the hole issue is becoming a major concern for all operators in a marine environment, where all conventional technologies fail.

Promac water treatment has anticipated on this reality already since '94 with the advanced Promac Aquacleaner MAR-C-BW series specially developed for shipboard applications.

The nasty emulsified bilgewater cocktail can now be treated to safe discharge water and concentrated a minimum concentrated waste volume without using chemical consumables.

This results in optimal freedom of ship operation world wide including sensitive and arctic area's etc. etc.

More than 250.000 shipboard operaty hours with Promac Aquacleaner and valuable feed back from satisfied customers enable us now to present comparative results and payback time examples of investment for retrofit or new building applications.

In some cases even an almost zero discharge approach is feasible.

PROVEN TECHNOLOGY FOR ADVANCED BILGEWATER TREATMENT

PROMAC AQUACLEANER-C-BW

Contribution to “The Maritime Environment” Bremerhaven conference
September 2001
by V. Korteling

INTRODUCTION

Promac has its roots in the shipbuilding and shipping business since the early 60-ties and expended with the watertreatment separation activity in 1978 as an independent OEM-er specialised in membrane separation for AQUASET RO-freshwater generators and AQUACLEANER waste water treatment systems.

PROMAC is an ISO 9001 and AQAP 110 certified company and a separations systems supplier since 1978 including government watertreatment systems since 1982.

PROMAC AQUACLEANER-C-BW for separating oily-water/emulsion mixtures like bilgewater, is a development of PROMAC Watertreatment Division since 1992 and was sponsored by CMO Maritime research coordination agency and DGSM Netherlands Shipping Authority.

The Netherlands Navy was very much interested from the beginning and has supported with practical facilities. The NATO working group on environmental issues has been informed from the beginning.

The proprietary AQUACLEANER technology is based on a special integration of cross-flow micro filtration and gravity separation and has proven to be very efficient and cost effective.

DEVELOPMENT RESULTS

During ‘94 - ‘96 many lab. tests and shipboard practical performances have been realised. To day, mid 2001 AQUACLEANER units are in operation on board of NATO Navy Ships in the Netherlands, Norway, Germany and UK government inspection and arctic expedition vessels, commercial shipping, dredging and offshore contractors with altogether over 200.000 operating hours.

In the NIAG SG 50 study on "NATO Environmentally Sound Ship of the 21st Century" the AQUACLEANER technology was identified as shipboard proven and commercially available (sheet L-O tech 3A EQI integrated MFGS).

Verified by many independent tests, performed by several customers themselves WTD71 (GE), DERA (UK), KM (NL), the discharged water usually contains not more than 2 - 5 ppm residual oil IMO MEPC 60(33) certification is recorded already in 1995 and repeated in 1998 as first high performance separator for emulsified mixtures.

As equally important achievement is the dramatic volume reduction that saves considerable costs for storage and final harbour off load or incineration discharge of the residual dirty oil.
Aquacleaner is ready now already as a proven solution for future IMO regulations as now under preparation.

PRINCIPLE OF SEPARATION PROCESS

To solve the very serious problems in shipboard practice with separation of emulsified oily-water mixtures (both mechanical and chemical emulsions) ***an entirely new approach*** proved to be necessary compared to all conventional systems because effective and reliable treatment of such mixtures goes beyond the limits of all processes where the specific density is determining for the separation results (stokes law), incl. hydrocylones and centrifuges.

A barrier separation on particle size (emulsion droplets) is necessary in order to guarantee a reliable continuous process ***without using chemical consumables.*** Consequently membrane separation has to be part of the final solution.

The entirely newly developed proprietary PROMAC AQUACLEANER technology fulfils these preset requirements. It combines in a special integration of cross-flow micro membrane filtration and gravitational separation in a integrated closed loop process with automatic PLC control.

Fig. 5 shows the principle of operation and fig. 9 ships integration

In the first section is a special process tank where most of the free oil is separated and collected in the top of the container. In the heart of the AQUACLEANER, the circulation loop for cross-flow micro filtration, most of the water is separated from the remaining mixture.

The retained concentrate is transferred automatically to the process tank to join the free oil layer in the top. Resp. to be recirculated.

When a certain level of oil is collected the discharge to the dirty oil tank is performed automatically or manual.
In this unique way ***two fundamentally different separation technologies have been integrated*** in a very effective automatic continuous closed loop process

After start up the AQUACLEANER system accepts automatically without adjustment any variation in oil in water content and fluctuations in emulsification and pollutants that usually occur in ships bilgewater.

Fig. 10 lists the specific characteristics and associated practical advantages

MEMRANE SEPARATION

Because the membrane separation process is decisive for the continuous undistributed performance it needs closer attention.

The natural fouling of the membrane surface is counteracted effectively by a hydropholic membrane with the cross-flow velocity effect and a unique automatic pneumatic hydraulic back pulse (outside to inside) regime to ensure continuous undisturbed operation (see illustrations fig. 6, 7, 8). Further periodical cleaning is under normal circumstances limited to a minimum routine operation with normal biodegradable cleaners (one every 3 - 4 weeks).

Prior to the full scale pilot test of complete units practically all available membranes have been evaluated including our experience from the oil and gas industry applications. As proven best reliable solution we use in AQUACLEANER special tubular ceramic membranes because of the chemical stability, temperature resistance, the very effective back pulse and long membrane life time. (6 - 10 years).

SHIPS ENGINEERING / INTEGRATION

Fig. 9 shows the proposed ships integration principle as applied in all new building projects.

Because AQUACLEANER preferably is operated 24/24 hrs around the clock the collection tanks is rather essential as a buffer.
The availability of transfer facility of water bottoms and oil tops from the dirty oil tank and collection tank respectively is optional to the naval engineering to decide on.

This option can help to optimise overall oil water management and associated cost saving considerably.

Promac specialists are available to cooperate for installation engineering or re-engineering for special versions whenever required.

OPERATIONAL RESULTS IN SHIP BOARD PRACTICE

Since '98 with accumulating all the 5 years experience the second generation design standard series has been completed and IMP MEPC 60(33) certified. Contracts have been signed for deliveries 2004 including a.o. all major new buildings for the Netherlands and German Navy and several major retrofit programs.

In future IMO regulations the bilgewater will be defined as "emulsified oily water mixture" in stead of "oily water".
Consequently a new approach is necessary. Aquacleaner is ready for the future.

Many fleet operators are planning to improve their environmental profile and to reduce the associated risks and costs.

Over 200.000 operational shipboard hours in a wide variety of application have generated valuable feedback information for operational scenarios based on real customer input and experience.

We have composed 3 operational scenarios of totally different practical applications (navy, commercial shipping and offshore contracting) which show the cost saving and pay back time of additional procurement costs (see fig. --- diagram simplified).

For the important emulsion oil/water issue now an adequate and thoroughly shipboard proven solution is available with the high performance PROMAC AQUACLEANER-C-BW in standard and customer adapted versions.

Several shipowners have realised practical results with AQUACLEANER in operational efficiency that pay back the investment **within 3 - 4 years** acc. to their own computations.

The table of characteristics and associated advantages (fig 10) illustrates the contributions:

* **increased freedom of operation**
* **better environmental compliance**
* **risk minimization**
* **cost saving operations**

AQUACLEANER is a good example where ***environmental protection, operational efficiency and cost saving go hand in hand.***

Originally we started with applications on various Nato Navy ships more recently commercial shipping and offshore contracting are involved and arctic expedition ships like HMS Enduvance, Arctic Sunrise and also the new Greenpeace flagship ESPERANZA.

PS PROMAC Watertreatment is also involved in advanced AQUASET RO-freshwater generators since over 20 years and AQUACLEANER MAR-GW grey water treatment is under development for shipboard and industrial applications.

See also leaflet ***PROMAC AQUACLEANER MAR-C-BW*** advanced high performance membrane separator for emulsified oily water mixtures.

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PROMAC BV

PROMAC AQUASET MLT MK 1
“MINIMODU”

THE ADVANCED LIGHTWEIGHT WATER PURIFICATION UNIT SINCE 1992 IN OPERATION BY THE NETHERLANDS UN MISSIONS IN CAMBODIA AND SINCE EARLY 1994 ALSO IN FORMER YUGOSLAVIA.

PROMAC BV

PROMAC AQUASET® NAV 24 SSP

SPECIAL UNIT FOR THE M-FRIGATES.
FULL AUTOMATIC PLC CONTROLLED WITH UF PREFILTRATION.

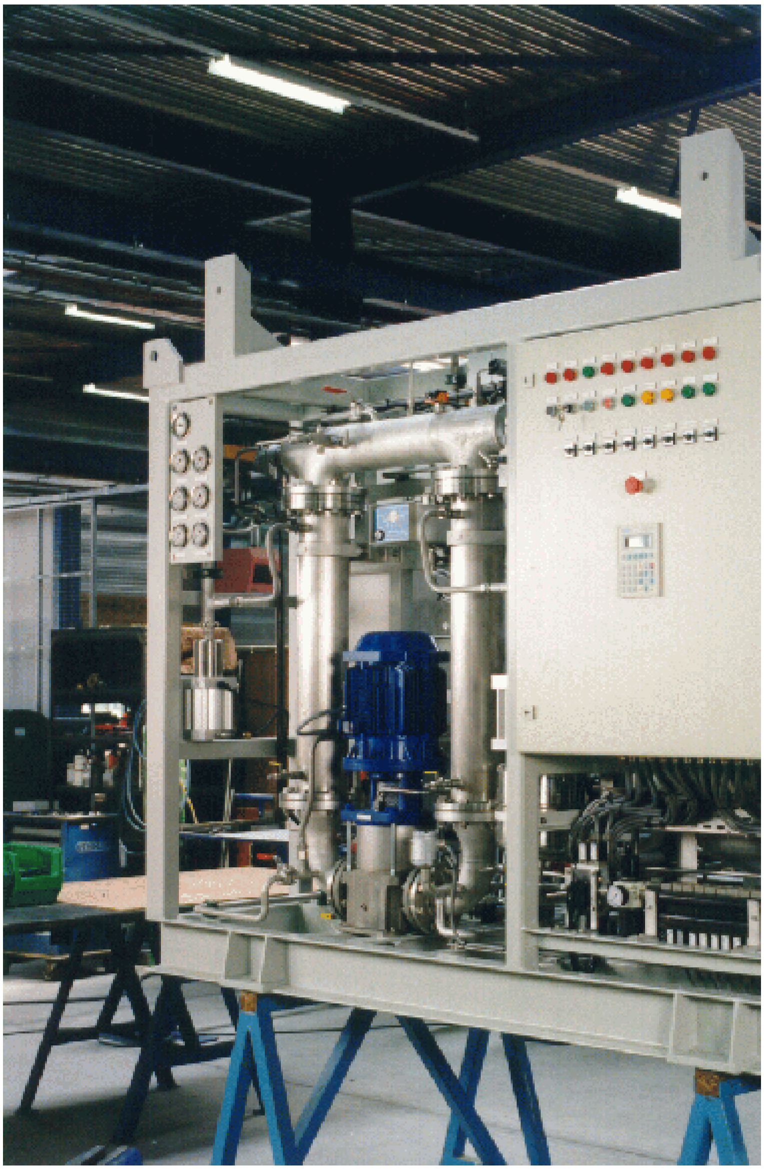
CAPACITY	**24 M^3/24 HRS** **(TDS < 500 PPM**
DIMENSIONS	**2000 X 1800 X 1600 MM**
WEIGHT	**3500 KG**
POWER	**440 V - 3 PH - 60 HZ, 22 KW**

NOTE **SHOCKPROOF TESTED AT 20 G 50 MSEC**
EMC APPROVED

PROMAC BV

PROMAC AQUACLEANER-MAR-C-BW

THE ADVANCED MEMBRANE BILGEWATER SEPARATOR



TYPE 2-S-48 UNDER CONSTRUCTION FOR THE NETHERLANDS LCF AND GERMAN F124 PROGRAMM.

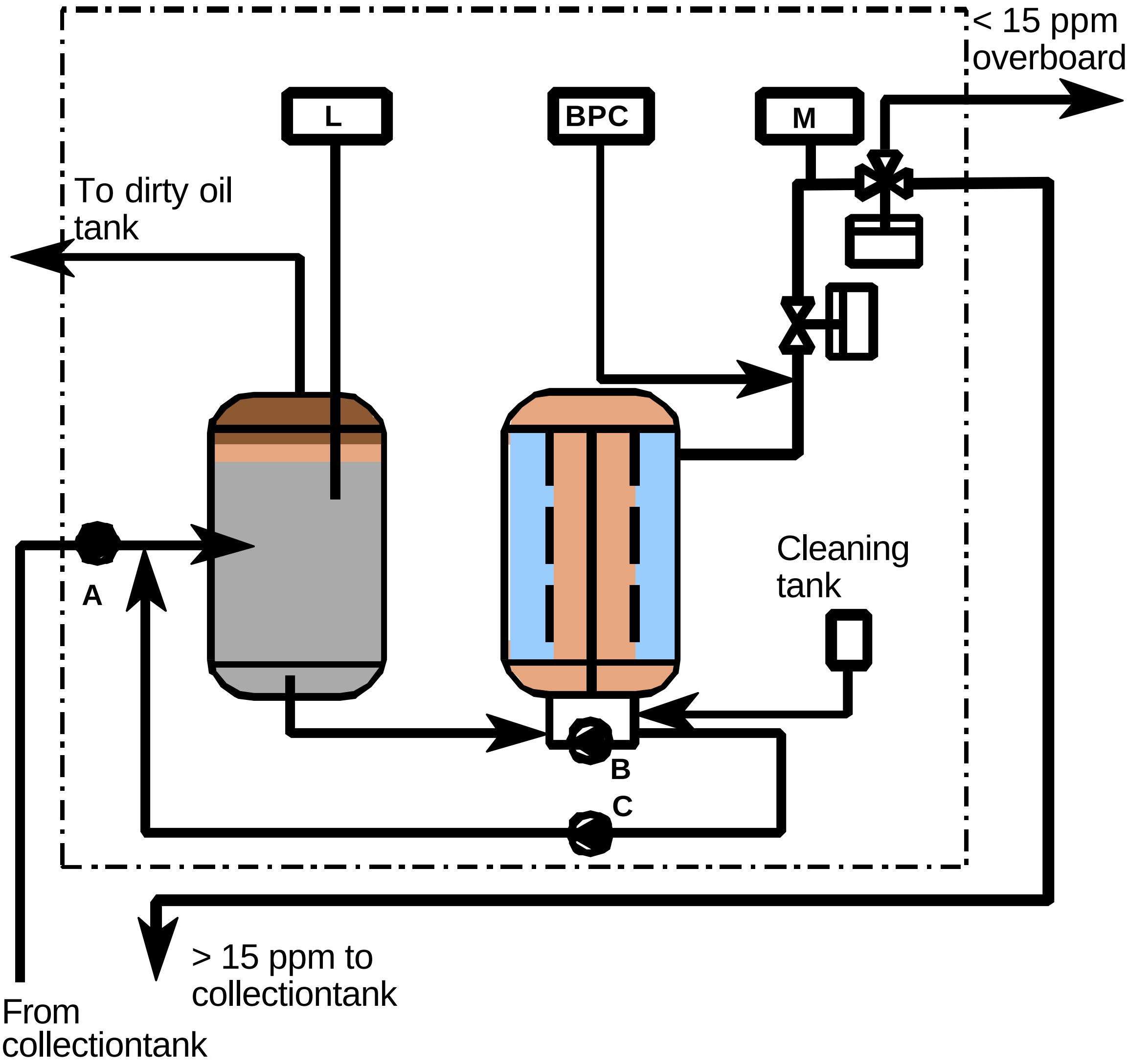
AQUACLEANER-C-B IS THE WELL PROVEN HIGH PERFORMANCE SEPARATOR FOR ALL TYPES OF BILGEWATERS INCLUDING EMULSIFIED MIXTURES.

IMO TYPE APPROVAL CERTIFICATE FOR THE FULL RANGE SI/60-64/98

PROMAC BV

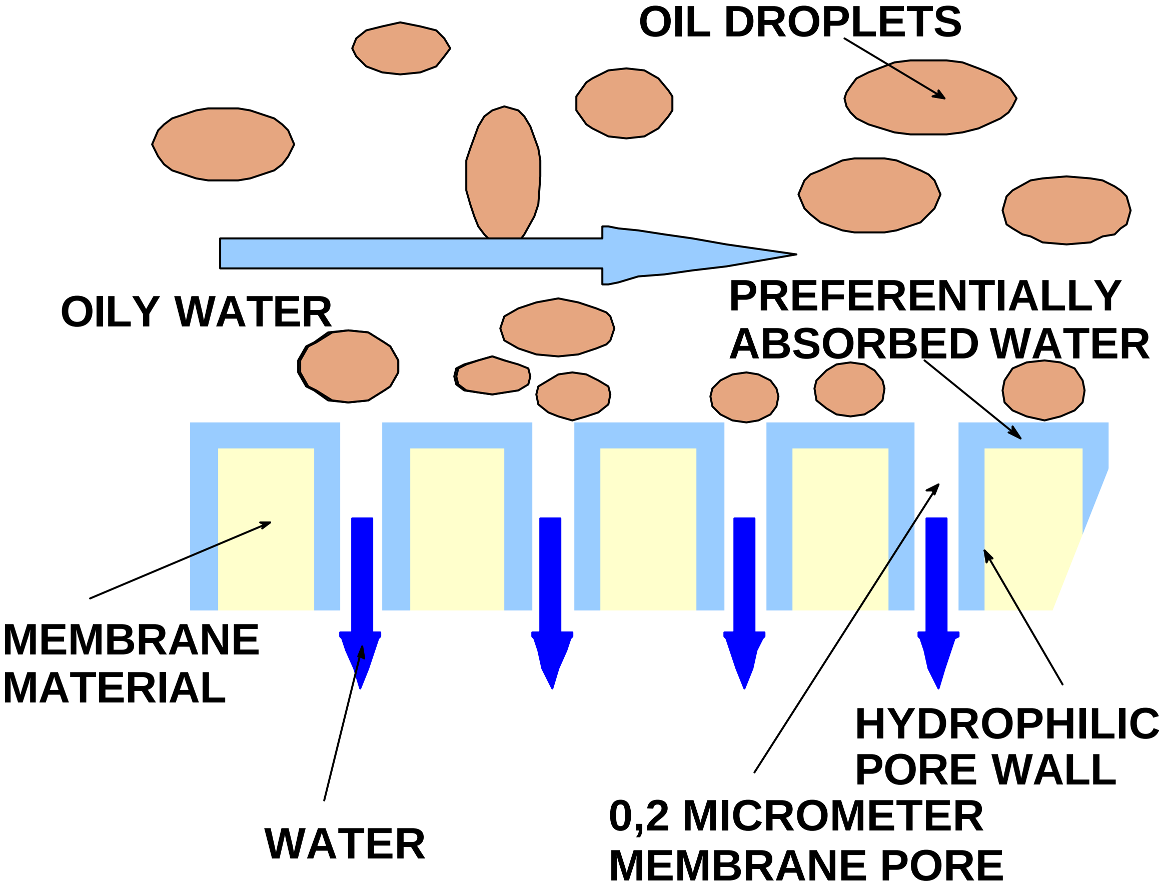
AQUACLEANER-C-BW

PRINCIPLE OF OPERATION



PROMAC BV

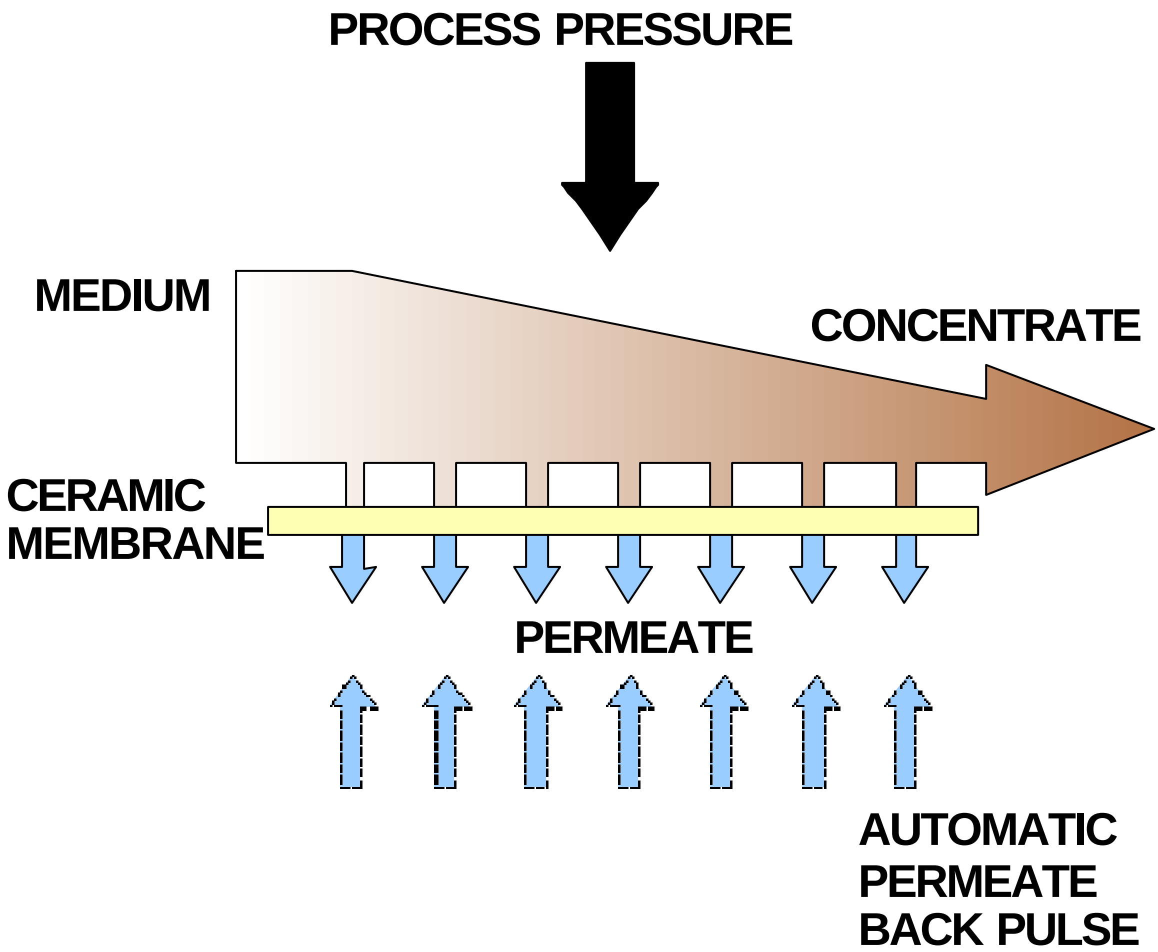
THE PRINCIPLE OF A HYDROPHILIC MF MEMBRANE



THE WATER ABSORPTION ON THE HYDROPHILIC PORE WALLS INFLUENCES THE RETENTION OF OIL DROPLETS

PROMAC BV

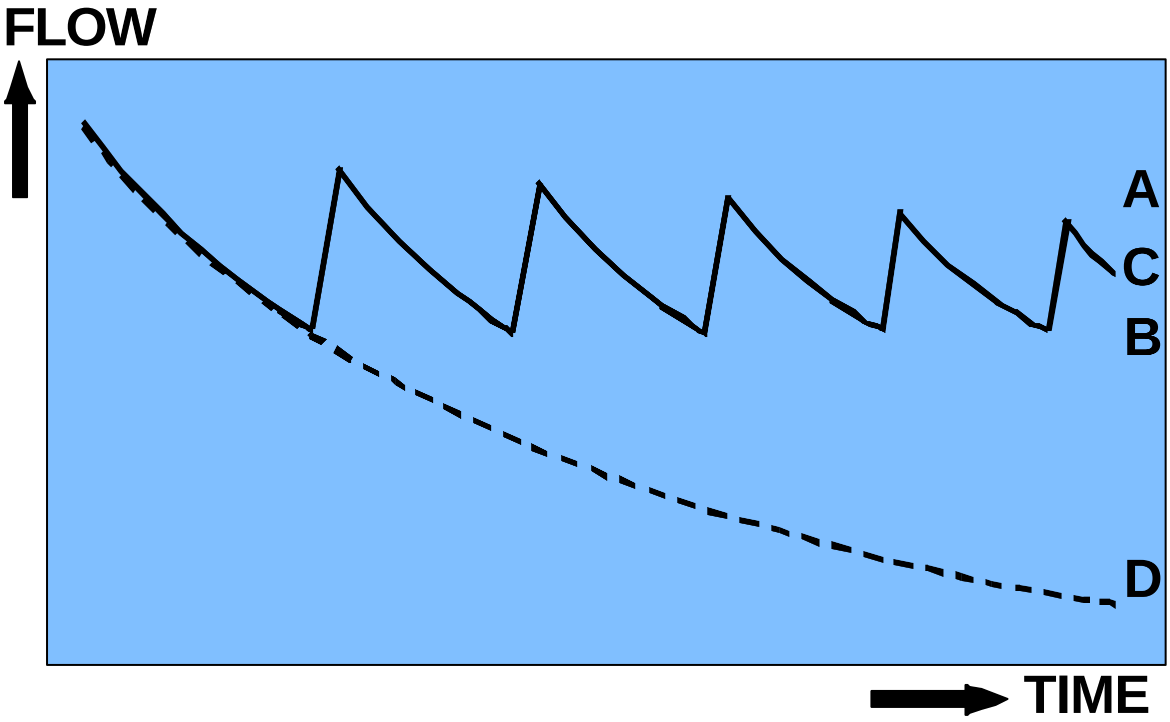
THE PRINCIPLE OF CERAMIC MF MEMBRANE WITH BACKPULSE



PRINCIPLE OF THE SEPARATION PROCESS

PROMAC BV

THE PRINCIPLE OF CERAMIC MF MEMBRANE WITH BACKPULSE



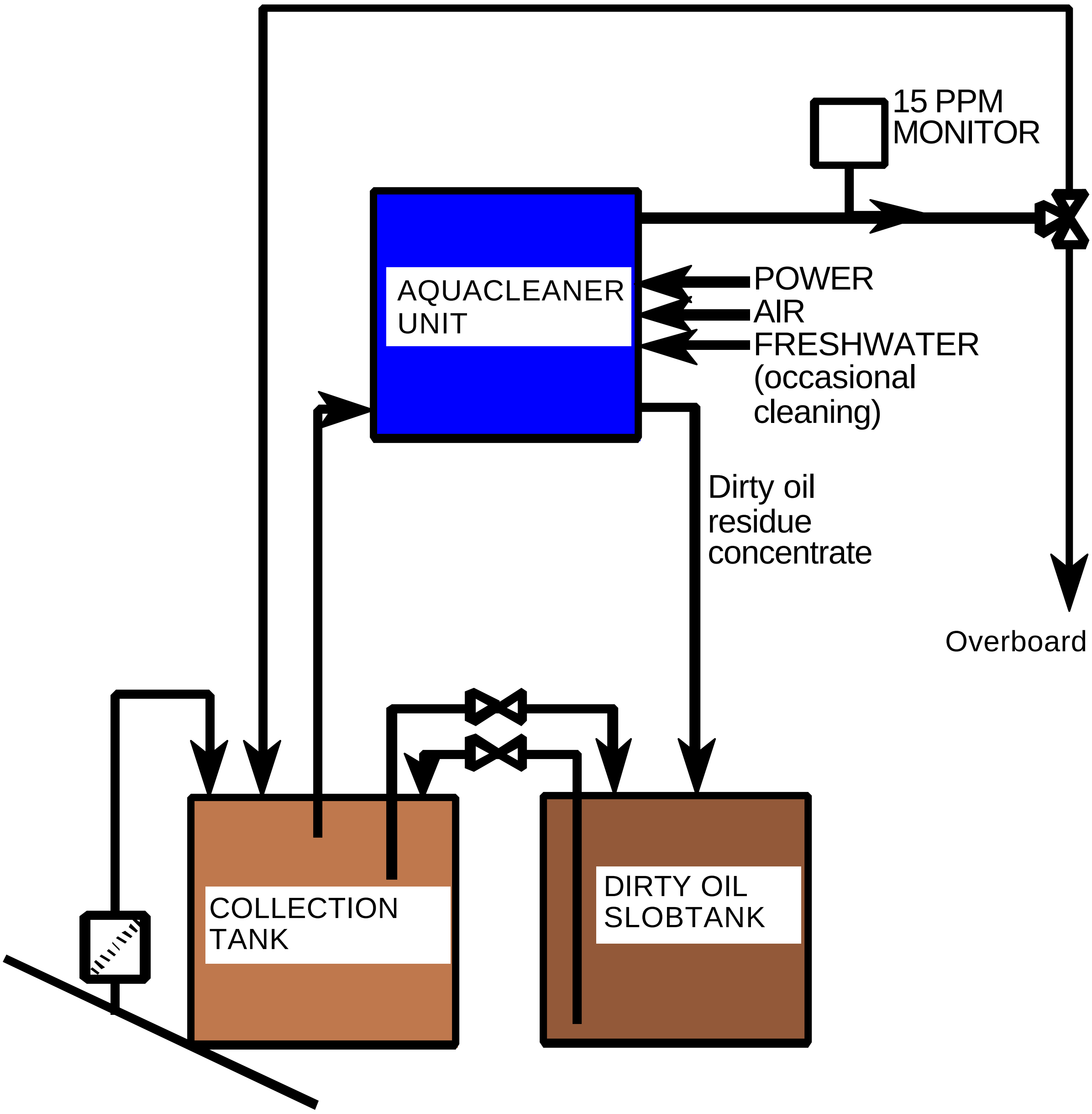
A = AFTER BACKPULSE
B = BEFORE BACKPULSE
C = WEIGHTED AVERAGE
D = NO BACK PULSE

PERMEATE FLOW AS A FUNCTION OF TIME

PROMAC BV

AQUACLEANER-C-BW

SHIPS INTEGRATION PRINCIPLE



PROMAC BV

AQUACLEANER-C-BW

MAIN CHARACTERISTICS & ADVANTAGES

* Insensitive for emulsified oily-water mixtures and variation in bilgewater composition and oil content
  > ***Continuous automatic operation***

* Insensitive for seagoing movements
  > ***Continuous automatic unattended operation***

* Safe discharge of treated water < 15 ppm oil (< 5 ppm)
  > ***No limitations in operational freedom and no risk for spoils and associated calamities***

* Maximum volume reduction - minimum volume of contaminated oil
  > ***Lower costs for storage and harbour discharge or easy to incinerate.***

* No process consumables - additives
  > ***Low operational costs***

* Compact small foot print stand alone unit
  > ***Easy to install for new building and retrofit applications***

* Simple and reliable
  > ***No extra labour constraints***

PROMAC BV

AQUACLEANER-C-BW

TYPE RANGE SPECIFICATION AND CAPACITIES

TYPE SPEC	NOMINAL CAP. M3/24 HR	IMO MEPC 60/33 CERTIFICATION	IMO TEST CAP. M3/HR	NSI SUBDIVISION INSTALLED POWER TOTAL IN KW	NSI CAP. M3/HR
2-S-6	0,5	SI/60/98-5111-1	0,03	I < 1000	0,025
1-S-24	1	SI/61/98-5111-1	0,06	II 1000-5000	0,05
2-S-24	2	SI/62/98-5111-1	0,12	III 5000-10.000	0,1
2-S-48	4	SI/63/98-5111-1	0,24	IV > 10.000	0,2
4-S-48	8	SI/64/98-5111-1	0,48		

NSI = NETHERLANDS SHIPPING INSPECTION

PROMAC BV

AQUACLEANER-C-BW

DIMENSIONS AND WEIGHTS

TYPE SPEC	AQUACLEANER SKID		FEEDPUMP + E- MOTOR SKID		POWER
	dim L x B x H	weight kg dry / op.	dim L x B x H	weight kg	total kW
2-S-6	850x850x1800	350 / 430	900x280x340	40	1,25
1-S-24	1050x1000x1800	450 / 700	800x300x430	40	6,40
2-S-24	1050x1000x1900	450 / 700	800x300x430	60	6,60
2-S-48	2500x1100x1800	1000 / 1500	1000x300x400	60	8,25
4-S-48	2800x1500x2000	2000 / 3000	1200x400x500	80	8,65

CONTROL BOX AND OIL CONTENT MONITOR (1000x800x300 80 kg)
ARE EXTERNAL ARRANGED FOR TYPES 2-S-6, 1-S-24 AND 2-S-24

PROMAC BV

PROMAC AQUASET AND AQUACLEANER

DESALINATION AND PURIFICATION SYSTEMS FOR SHIPING = OFFSHORE = NAVY = DEFENCE AND INDUSTRY

WORKSHOP IMPRESSION JUNE 1998

LEFT DOWN: **TESTING OF MOBILE DEFENCE SYSTEMS AND AQUASET "ECONOMIC"**

MIDDLE: **TWO UNITS AQUASET-EC-SP FOR FAST COASTGUARD CUTTERS**

RIGHT TOP: **TWO UNITS AQUACLEANER-C-BW FOR NATO NAVY FRIGATES**

PROMAC BV

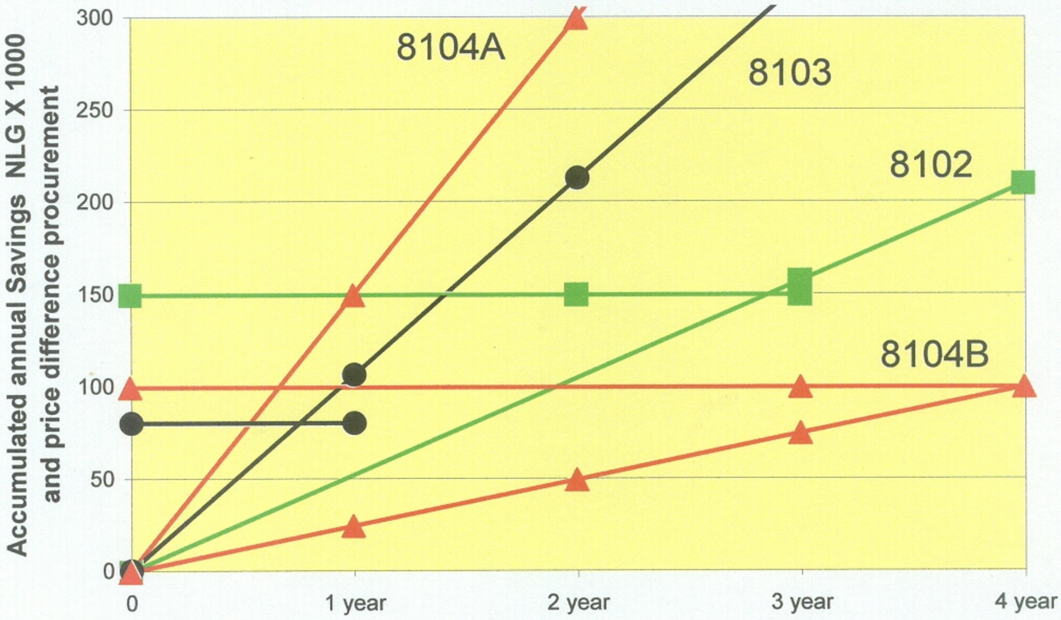
PROMAC AQUACLEANER C-BW

advanced separator fot emulsified oily-water mixtures

Cost savings pay back investmentprice difference
with convential alternatives

3 - cases different applications

(simplified diagram)



for details of operatinal scenario consult seperate discription.

8102	150 days p.a with 2 m³/day average Reduction with AQUACLEANER 90 m³ p.a.	
8103	250 days p.a with 1 m³/day average Reduction with AQUACLEANER > 180 m³ p.a.	
8104	300 days p.a with 10 m³/day average Reduction with AQUACLEANER 300 m³/ p.a. chemical concumption for flocculation.	8104 A 8104 B

Savings computed with NLG 500 / m³ waste reduction

CURRICULUM VITAE

Michael Neubold
SG I 5
Environmental Protection Management

Born	March 30th, 1966	in Mühlacker, Baden Wuerttemberg
Education	June 1986 1987 to 1993	German High School Degree (Abitur) University of Karlsruhe Master of Science Mech. Engineer
Military Service	July 86 to Sept. 87	Basic military service within the German Armed Forces
Professional Background	May 94 to Dec. 95	Preparatory service for senior-level civil service technical career in the Bundeswehr Administration
	Dec. 95 to June 97	Assistant Head of Section for acoustic protection
	Since June 97	Assistant Head of Section for environmental protection equipment on ships and Assistant Head of Section SG I 5.
	Jan. 00 – Jan. 01	Participation in The Exchange Program for Scientists and Engineers between the US and GE Armed Forces

Present Actives

Preparation of environmental protection concept for
Clarification of fundamental questions regarding environment protection

Environmental protection coordinator of Section SG

International cooperation with NATO nations and dealing with inquiries from other nations

German spokesman in NATO/ AC/ 141 (SWG / 12) „On Maritime Environmental Protections“

Postdesign services for environmental protection equipment on ships in service

Coordination of and dealing with research and technology
Monitoring of construction regulations

Cooperation with the standardizing body for marine engineering and technology

Michael and Ruth Neubold are the parents of Dorothe (8 years) and Marius (4 years).

Abstract

Michael Neubold
SG I 5
Environmental Protection Management

"Progress of sewage treatment technology onboard German Navy vessels - Frigates class 124 versus Sail Training Ship GORCH FOCK -"

Introduction
In 1992 the BWB started a R&D-Program in the area of sewage treatment technology. This program was a result of a decision made by the North Sea Conference to make more effluent testing of sewage treatment plants (STP) in the future.

R&T-Activities
In a first step existing STP were examined under onboard conditions. Therefore a simulator for typical movement of a frigate was installed on a municipal sewage treatment plant to examine different types of shipboard STPs.

Sewage Treatment System onboard Frigates Class 124
The outcome of this first step was a retrofit program for existing plants onboard vessels and guidelines for the design of “conventional” STPs. One example for such a conventional system is the STP of the new frigates class 124, the“Saxony”-Class. The design and integration of this sewage system will be presented and the main parameters will be shown.

Bio-Membrane-Reactor Tests
The tests within the R&D-program also showed that the effluent standards of conventional systems will be decreased when the system is faced to a certain sea state level. A secondary effect is the lost of the biomass because the gravity forced settling process is not able to work reliable in this conditions.
To fill this gap the settling tank was replaced by membrane filtering equipment. For the examination of the pros and cons internal and external membrane use were tested. Some R&D activities were necessary to examine fouling problems. The reached effluent standards were very good.

Bio-Membrane-Reactor onboard “Gorch Fock”
The outcome of this second step was a Bio-Membrane-Reactor with internal membranes. This system was tested onboard the supply vessel “Meersburg” for 9 months. As part of a retrofit-program a new STP on base of this test-plant was installed on the German Navy Sail Training Ship “Gorch Fock”. The presentation will show the integration of this new Bio-Membrane-Reactor. As the final result of all experiences with existing STPs and the results of the R&D-Program the goal for the design and integration of a sewage treatment system onboard German Navy vessels will be presented.

Progress of Sewage Treatment Technology onboard German Navy Vessels

Frigates Class 124
versus
Sails Training Ship “GORCH FOCK”

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(SG I 5)

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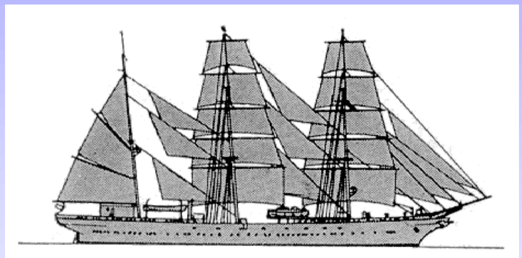
Content

- Introduction
- R&T-Activities
- Sewage treatment onboard F124
- Bio-Membrane-Reactor Tests
- Integration onboard “GORCH FOCK”

German Navy’s MEP Policy



The navy feels deeply obliged to make every effort to meet the requirements of MARPOL and other Conventions with respect to the equipment and operation of units afloat.

(Policy Directive " Environmental Protection in the Navy")

History

- In 1991 the “Regulation on the Prevention of Pollution by Shipboard Wastewater in the North Sea” came into force in Germany
- Decision of the “International Conference for the Protection of the North Sea Area“ to support inspections onboard ships

Effect onto the Navy Program

Besides IMO-certification by SeeBG* for sewage treatment plants (STP):

- Effluent tests during the general acceptance test at sea for new-build ships
- Systematical tests for Navy vessel's STP in service

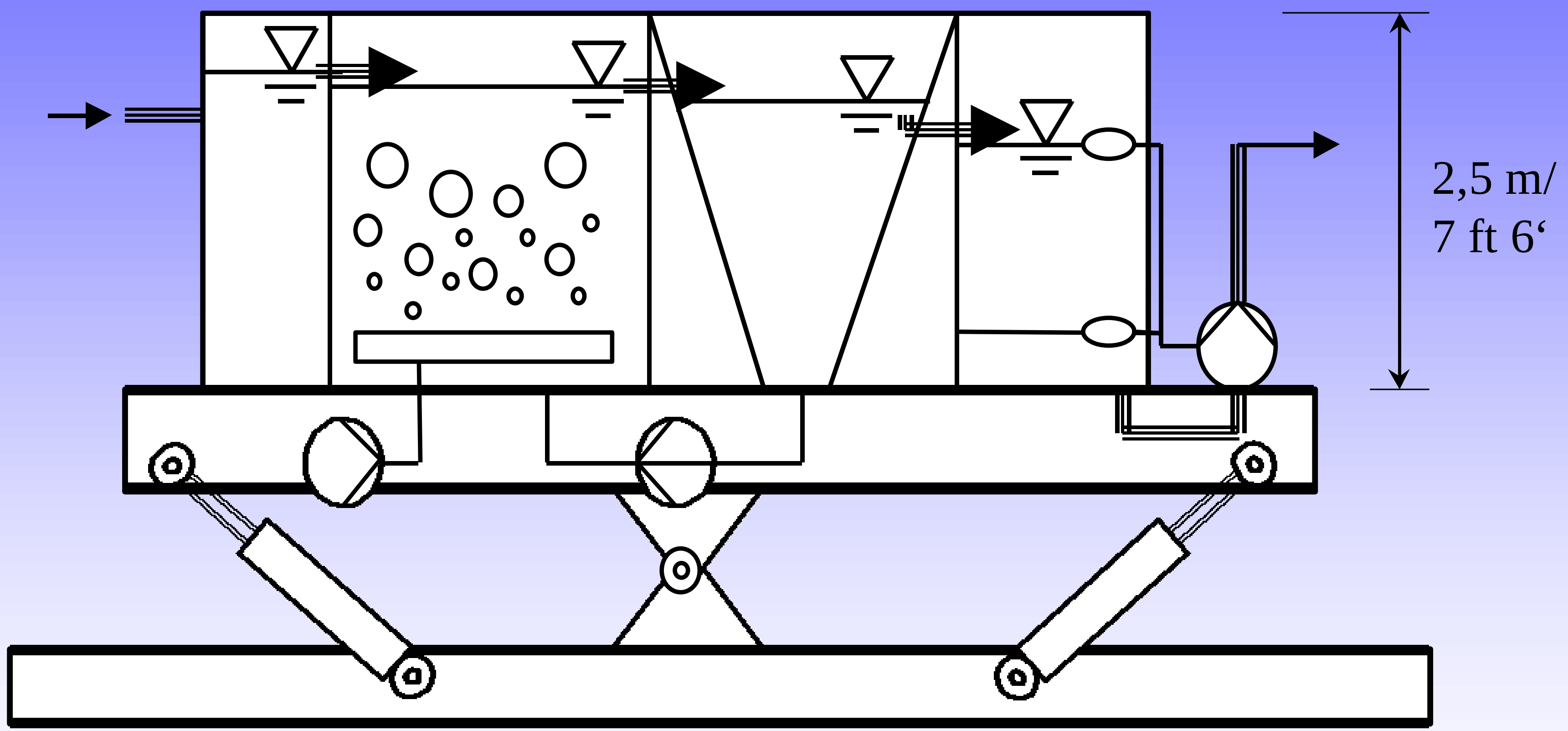
*SeeBG: Nat. Certification Society of GE

Basic R&T

- In 1993
  Desk-study about "The Improvement of the Performance of STPs"

- In 1994
  Trials with model-sized STP using different bio-reactor types and sedimentation mechanism

Simulation of Ship's Movement



Result of R&T Activities

- Need of equalization of hydraulic and organic peak loading over the day
- Bio-reactor "boxes" are not useful with regard to the flow pattern
- The air intake has to be optimized
- Gravitational sedimentation causes a number of problems

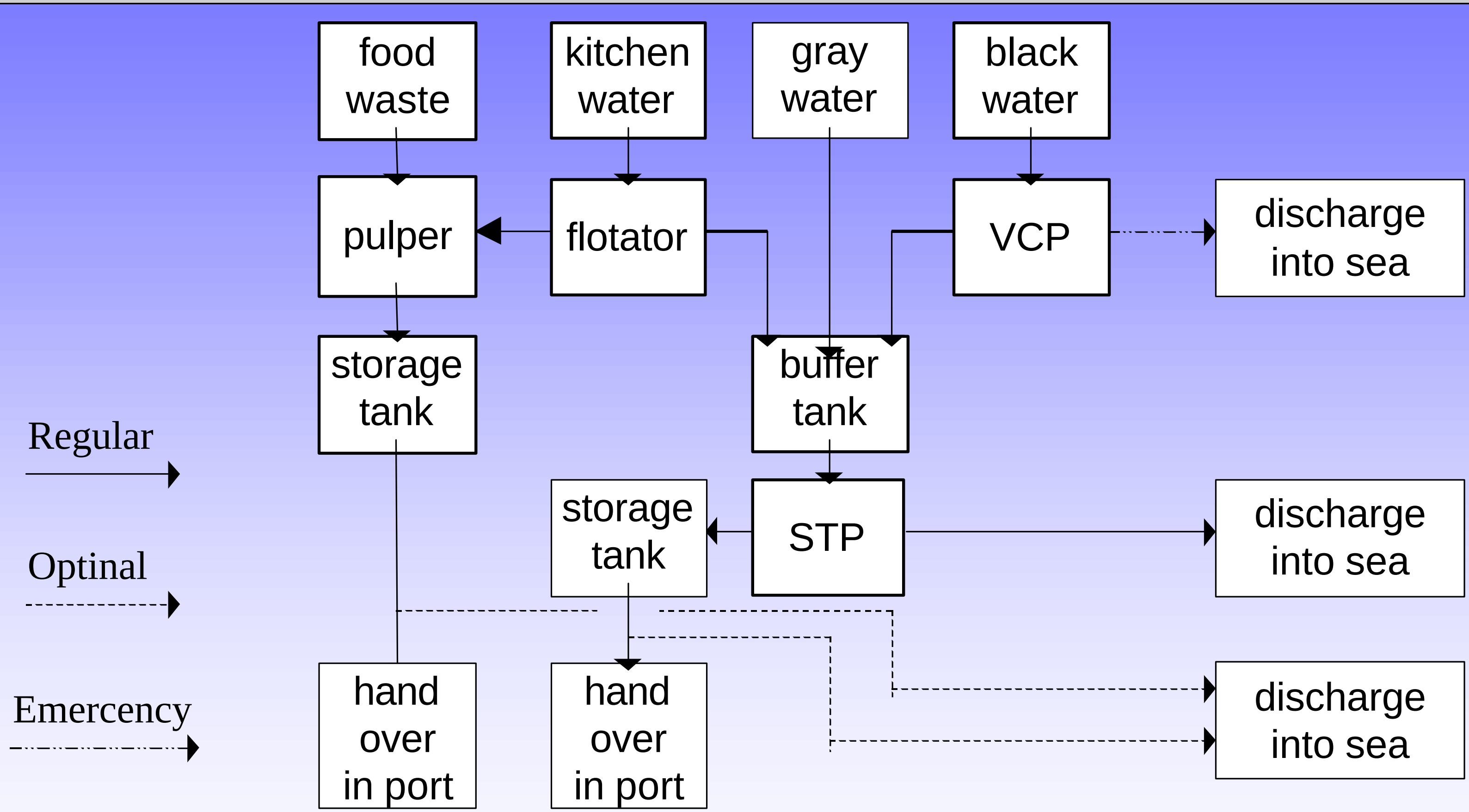
Result of R&T Activities

- Development of a concept for a wastewater treatment system onboard Navy vessels
- Guidelines for the design of conventional STPs mirrored on the set of rules by ATV*

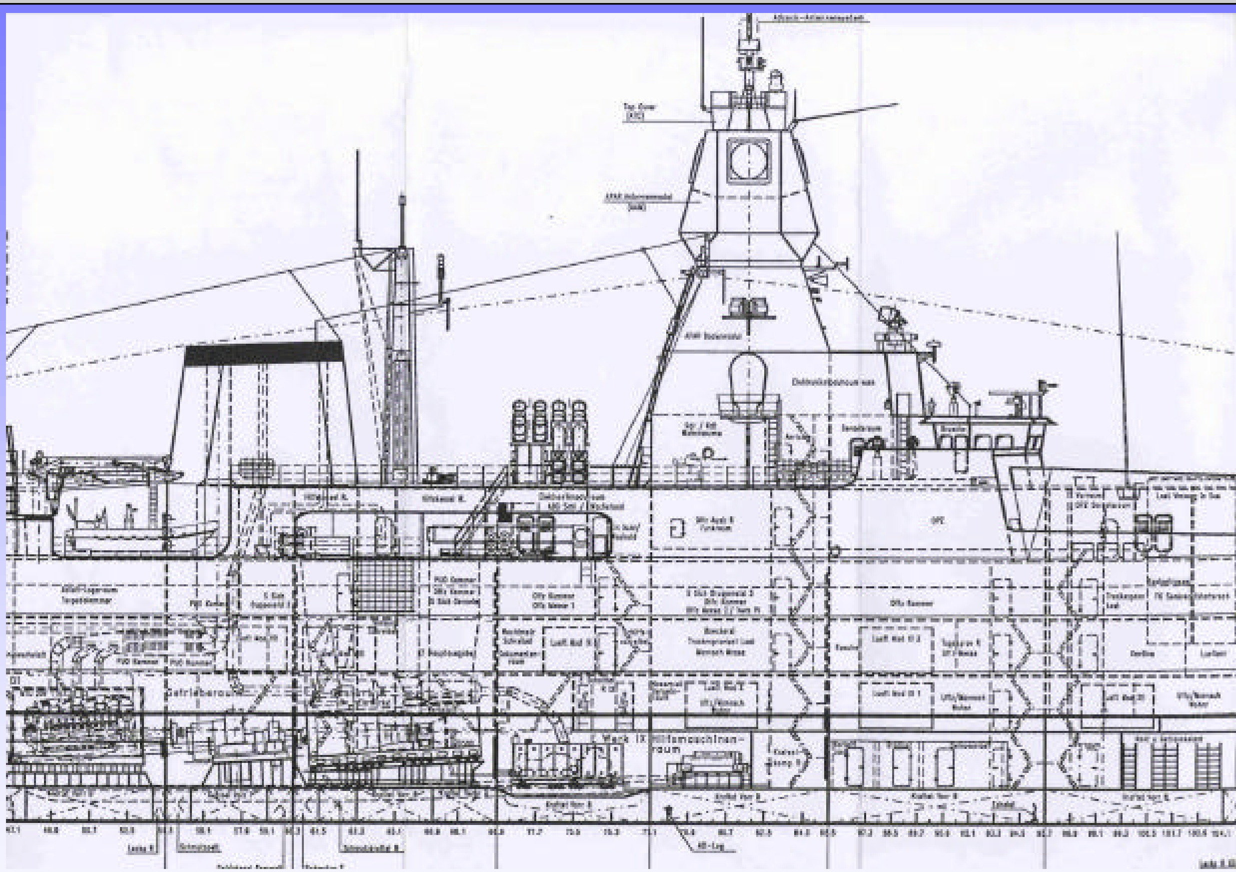
*ATV: Association for water, wastewater and waste
Abwassertechnische Vereinigung

Wastewater Treatment onboard F124

Wastewater Treatment Concept



Side View



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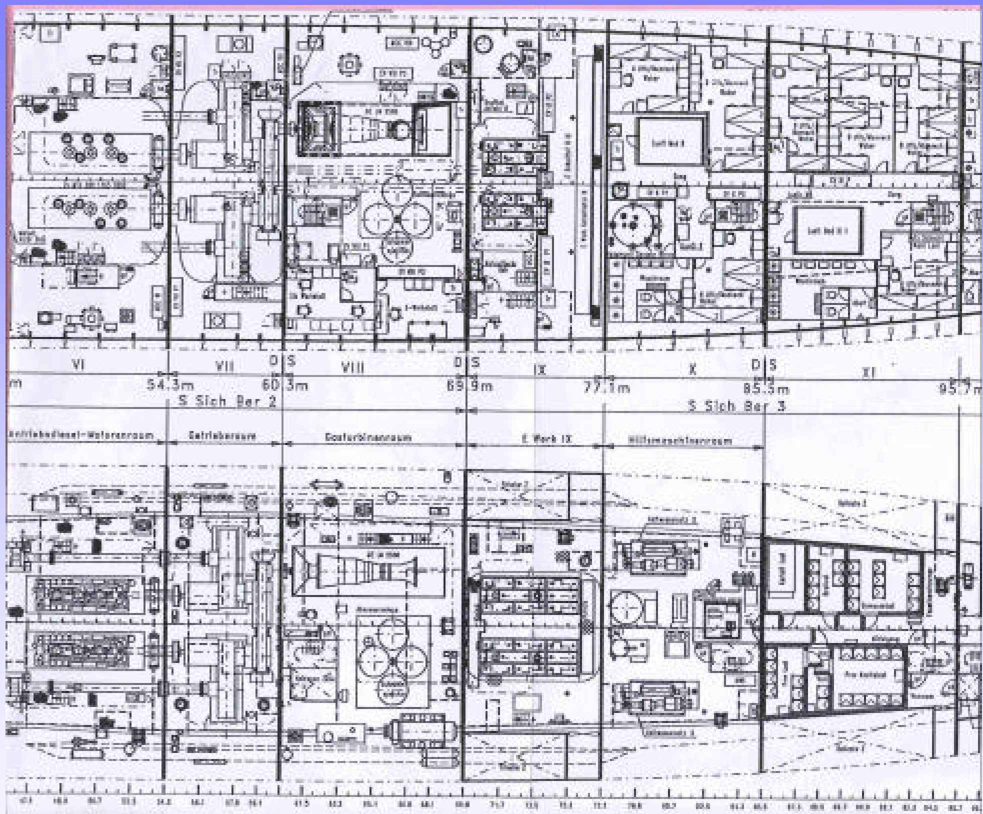
Sewage Treatment onboard F124 (cont.)

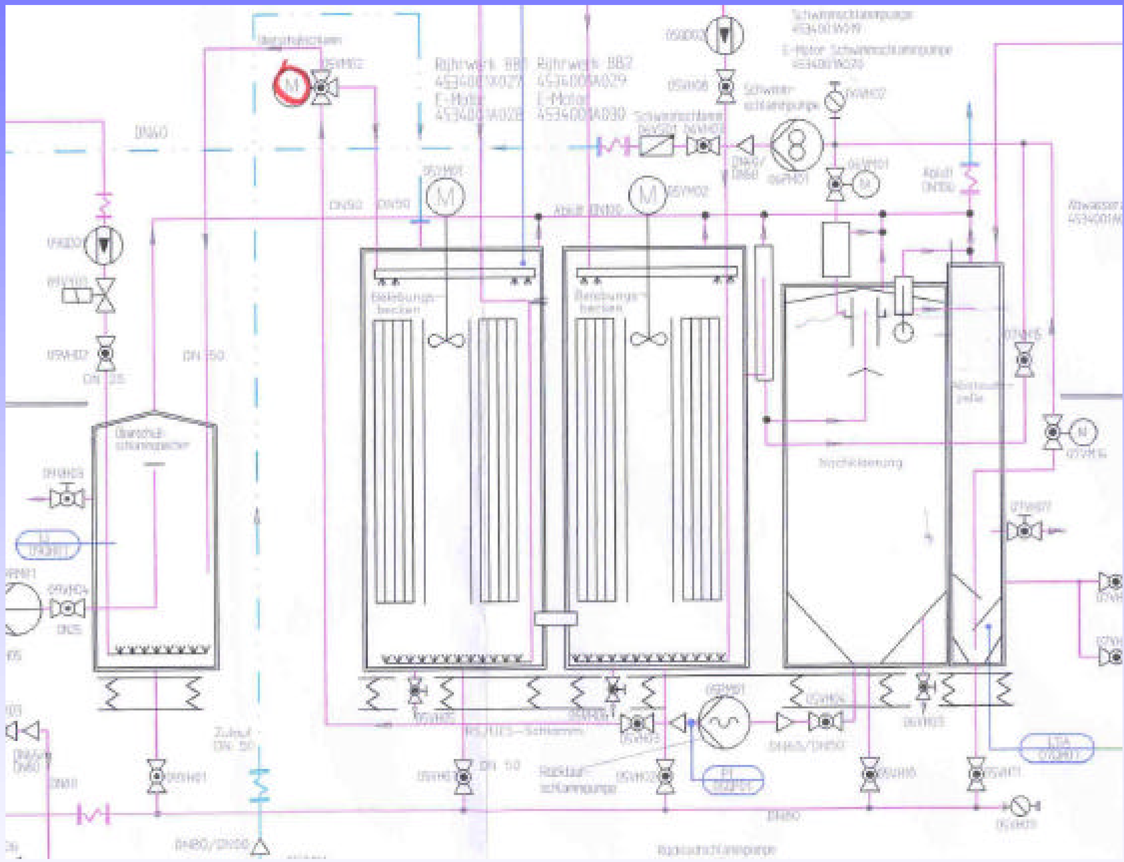
Top View



<u>Tank volumes:</u>

Equalization:	10 m³
Bio-reactor:	2*6 m³
Sedimentation:	6 m³
Disinfection:	1 m³
Sludge storage:	3 m³
Total:	32 m³

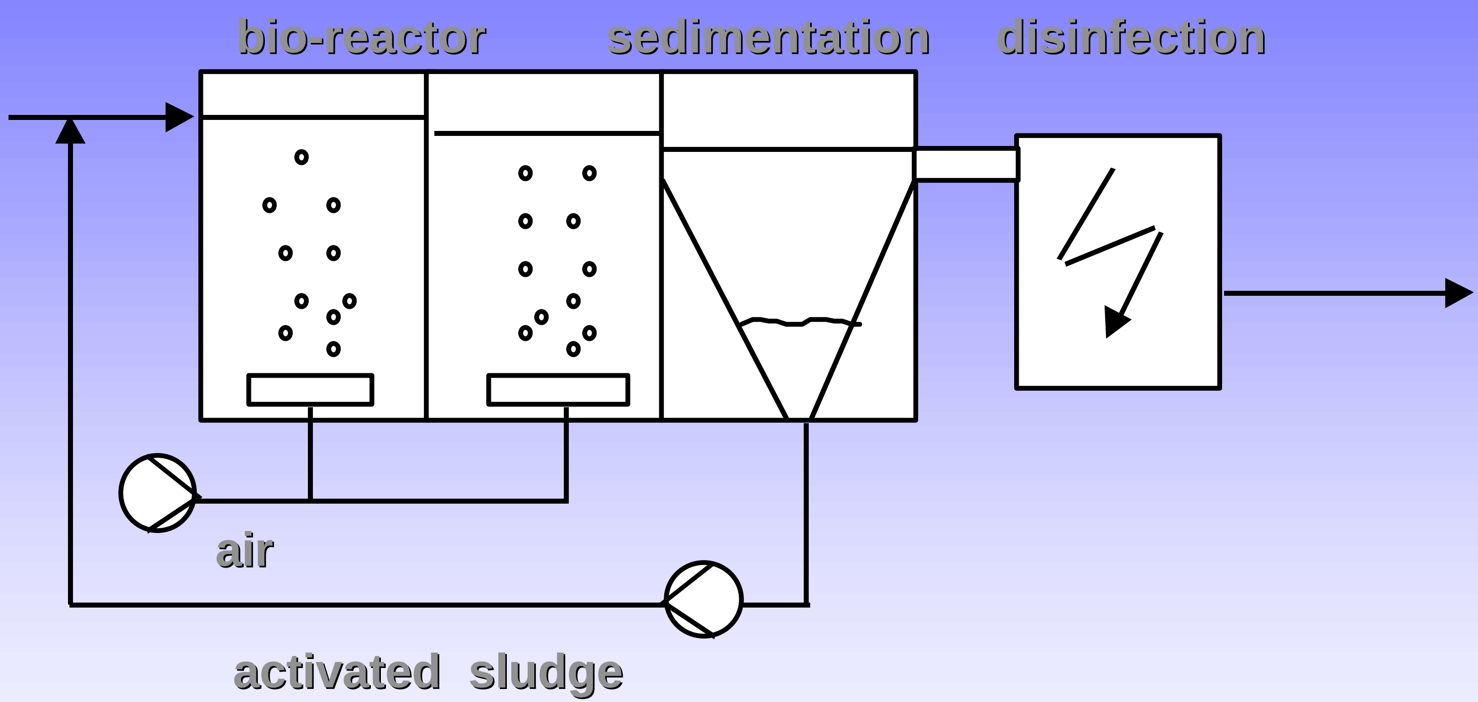
Main Dimensions



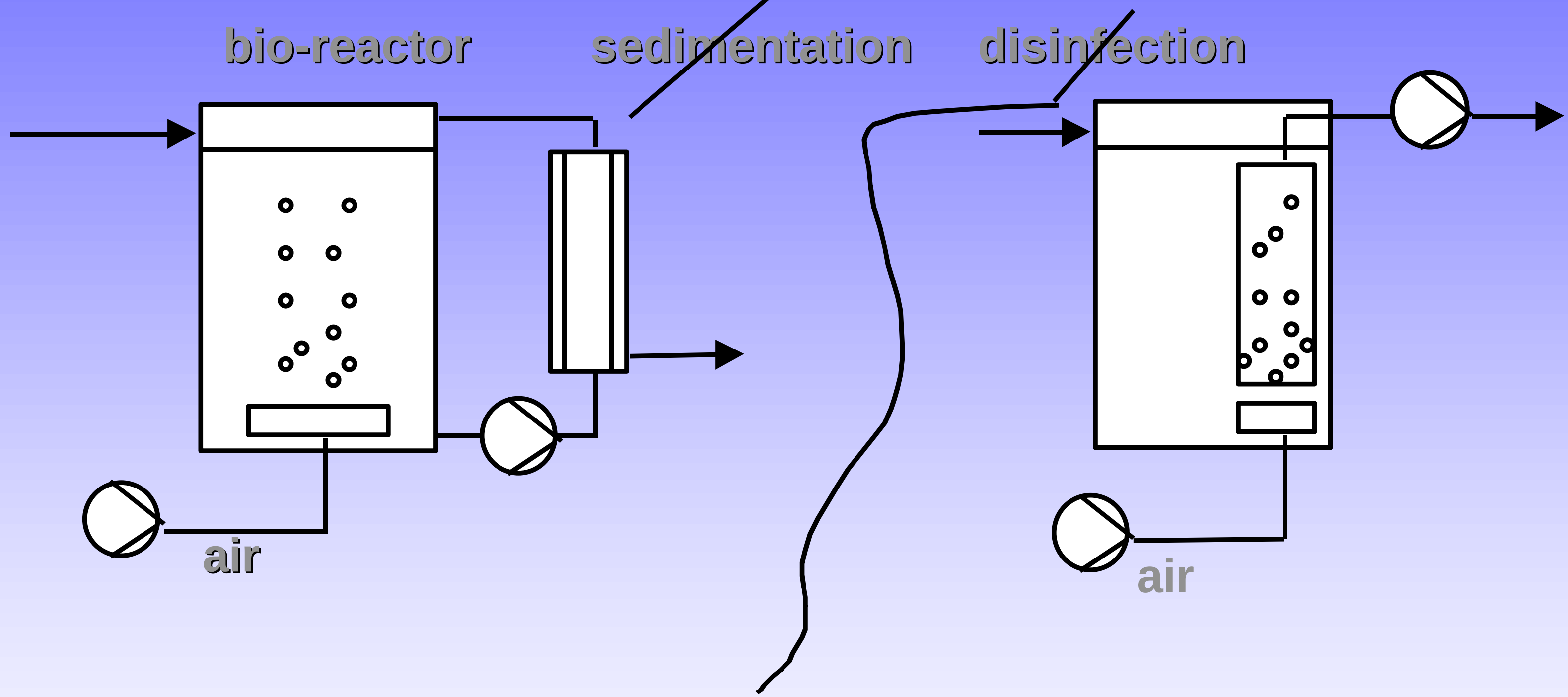
Length:	5,5 m
Width:	3,6 m
Height:	4,5 m
Weight:	12 to (empty)
	35,5 to (full)

Bio-Membrane-Reactor Tests

Conventional Bio-Reactor



Bio-Membrane-Reactor



Test Result

Land trials at the municipal sewage treatment plant of Altenberge

- Effluent data were next to the detection limits
- Regarding bio-degradation and reliability unit with internal membranes showed better performance
- No negative effect by wiping
- Potential of volume reduction

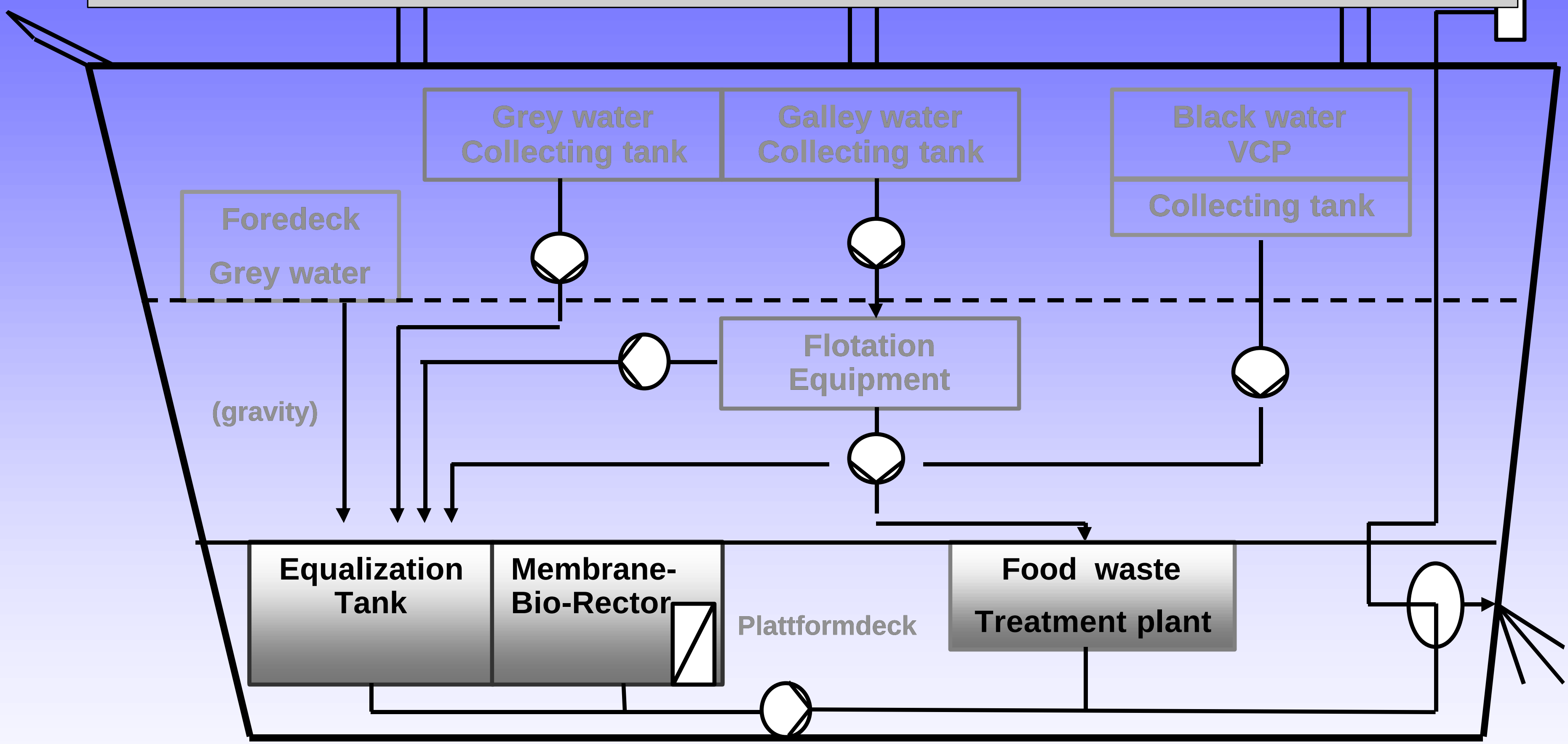
Test Result (cont.)

Sea trials onboard supply ship “Meersburg”

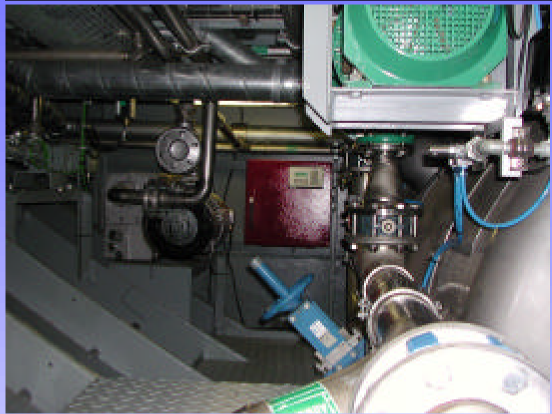
- Effluent data next to the detection limit
- No foaming problems but organic overload by kitchen wastewater
- No failures within a year
- Fully automatic, no actions necessary by crew

Integration onboard “Gorch Fock”

In-service-life Extension



Main Dimensions



Length: 4,2 m

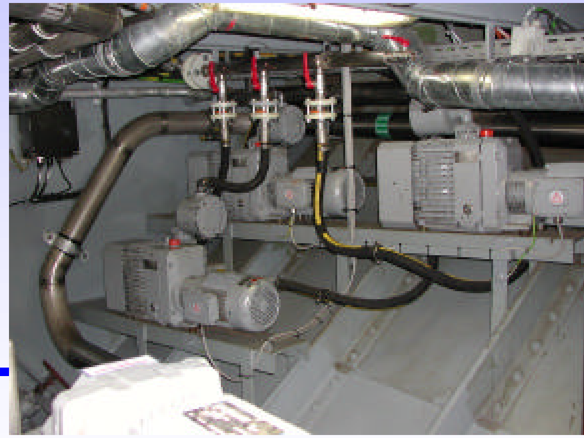
Width: 2,8 - 3,6 m

Height: 1,8 m

(Bio-Reactor and Equalization Tank)

Tank Volumes:

Equalization:	7,3 m³
Bio-Reactors and	
Sludge Storage:	16,4 m³
Total:	23,7 m³



Conclusion

- Several different types of STP are available on the market
- The limitation in space and the demand for a high reliability is the key requirement within the German Navy
- The real challenge is the integration of the STP into a ship design
- Bio-Membrane-Reactors give a lot of options in this process

CURRICULUM VITAE

Hen Boele.

After graduating as mechanical engineer from HTS Dordrecht (NL) in 1974, Hen Boele started as an R&D engineer in a major Dutch dredging company. He developed equipment for special applications like dredging in a mangrove forest or covering pipelines at the sea bottom. In 1982 he started his own company in the automotive business. Together with a patent, this company was sold to a Tampa based public company.

Research on solid-liquid engineering started in 1992, resulting in the first Rofitec filter patent.

In 1994, Delft University presented a booklet called ”Gravitational and centrifugal oil-water separators with plate pack internals”. Studying the theoretical flow patterns in stacked disk separators led to the Rofitec brush patent, which was filed in 1998.

Solits bv, a joint partnership between Hen Boele and a financial partner, exploits both patents.

Abstract

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"Separation of Solids and Liquids"

Rofitec.
Sedimentation in a static settling tank may be improved by the use of artificial seaweed. Rofitec combines such sedimentation supported by artificial seaweed with the use of artificial gravity in a simple batch process.

Two flanges with a diameter of 0,6 m are mounted on a motor driven vertical shaft at a distance of 0,9 m. A brush with the same diameter and which looks like the brush from a car washing machine is fitted between both flanges. A thin walled tube slides over both flanges, together forming a drum shaped watertight cylinder. With the drum running at high speed, the mixture is fed into the rotating cylinder. The solids are deposited while the liquid meanders in upward flow through the brush. The liquid leaves the drum via a collector. Once a given quantity of solids is collected, the drum is stopped, the thin walled tube slides upwards and the brush is accelerated while running in air. The solids swing out of the brush and are collected on a conveyor.

Rofitec allows separation of abrasive materials, which may be fed into the machine at very high dry solid contents of the influent.
Rofitec produces a very dry cake.
Rofitec is a simple machine with a footprint of 1,3 x 1,3 m.
Rofitec allows liquid-liquid separation of mixtures, contaminated with sludges or solids.

Text for Rofitec presentation:

1. Introduction:

My name is Hen Boele, CEO of Solits bv. I am a mechanical engineer and the patent owner of the Rofitec technology for which I want to draw your attention today. The name Rofitec is an anagram for Rotating Filter technology.
The Rofitec technology was patented in 1998 and tested in many land-based applications. Solits was invited to this seminar by one of the attendants for whom we thank him very much.
The Rofitec technology as presented today may be used for solid/liquid separation, the process also allows solid/liquid/liquid separation.

2. Rofitec 600/2.

Rofitec machines effectively separate solids from a mixture at low costs. The technology is based on artificial gravity, improving the settling velocity of the heavier and lighter particles. The patented Rofitec technology avoids friction between the particles and the liquid, thus preventing shearing.
The Rofitec process is independent of the size, the shape or the consistency of the solids. Rofitec allows a very high efficiency in separation, independent on the quantity of particles in the mixture.
The picture shows the waste water of a French fries processing plant, containing potato shell, earth, starch etc. Rofitec is able to remove all these products; of course no dissolved products will be removed.

3. Summary.

See slide.

4. Artificial seaweed.

Artificial seaweed improves the performance of a static decanter. A known solution is to use artificial seaweed (strands of fibre) hanging down from a grid, which is mounted on top of the settling tank. The fibre strands run down from the surface and touch the bottom of the tank. The artificial seaweed causes the water to flow in a very even pattern. Any unnecessary turbulence is avoided, allowing the solids to deposit. The artificial seaweed armours the cake of deposited solids, so no particles get back in suspension.

5. Rofitec technology.

Rofitec combines artificial seaweed with artificial gravity. The grid, which carries the artificial seaweed, is bend around a cylindrical inner drum. The seaweed touches the outer drum. Both drums are connected mechanically and rotate at the same high speed. (Approx. 2000-3000 rpm). The centrifugal force stretches the seaweed.

The mixture is fed at constant flow and at a very low supply pressure into the rotating drum. The mixture meanders upwards between the artificial seaweed, then the liquid leaves the rotating drum via a collector as known from conventional separators.

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During the delay time in the drum, the heavier solids move away from the axis of rotation and settle against the outer drum where they build a very solid cake. The strands of artificial seaweed armor this cake.
Any excess water is pressed out of the cake during the batch process.
The layer of solids grows until it almost touches the inner drum, causing the supply pressure to increase. The supply flow is interrupted and the drum decelerates fast as possible. Remaining water leaves the drum via the air discharge and flows back to the mixture supply line.

6. Brush of demo machine.

The pictures show a clean brush, together with a brush filled with slimes and a brush filled with abrasive material.
The orange brush is filled to its carrier.

7. Rofitec's discharge system.

When the drum has stopped, the outer sleeve is hydraulically pulled upward. With the sleeve in upper position, the drive motor is started again. At about 700 rpm the solids swing lose from the artificial seaweed. The drum is stopped again.
While the sleeve moves downwards, the solids are scraped down in a bin, on a conveyor or any other method of discharge. Then the machine accelerates to standard speed with an empty drum and at full speed, the supply pump is powered. The complete cleaning cycle takes about 4-5 minutes.

8. Rofitec's retention:

See graph. Note: 2000 rpm only.

9. Rofitec 600/2

The inverter controlled drive motor is flanged to a central hollow tube. The cylindrical main frame carries the central tube via silencers.
The drive shaft runs via the central tube downwards and drives the brush carrier and the drum sleeve. Shaped like a brush of a car washing machine, the artificial seaweed is mounted on the brush carrier, together with the upper and lower drum flange. The partly oil filled central tube carries the brush carrier via bearings. The drum sleeve connects to the brush carrier via O-rings. A locking device holds the drum sleeve in place while running.
The scraper assembly connects to the top flange of the main frame by three parallel hydraulic cylinders. Three cylinder operated hooks are mounted to the scraper. These hooks fit into the grove in the drum sleeve so the scraper can pull the drum sleeve upwards. The influent is fed by an external pump at low pressure into the drum via a central tube and is accele-rated by the vanes, mounted on the lower brush carrier flange.
The effluent leaves the drum via a static collector, as known from conventional separators.

10. Brush access without tools:

After opening the PLC controlled access doors, the splash screen may be hooked to the scraper.

After lifting the scraper, drum and splash screen, the brush and o-rings may be inspected.

11. Alternative 1: Separators.

See slide.

12. Alternative 2: Decanters.

See slide.

13. Rofitec's capacity.

Rofitec 600 may collect about 100-150 liters of concentrated solids before the discharge process begins.

After every batch, Rofitec needs 3-5 minutes for the discharge cycle. The effective quantity of processed mixture per hour is dependent on the frequency of discharge cycles.

The graph shows the effective capacity in m3/hr against the volume of dry solids in the influent and at various flows of the supply pump.

14. Solits'targets

See slide.

15. Sales organization.

See slide.

16. Solits offers to its partners:

See slide.

17. Solits demands from its partners:

See slide.

18. Present status.

See slide.

19. Summary.

See slide.

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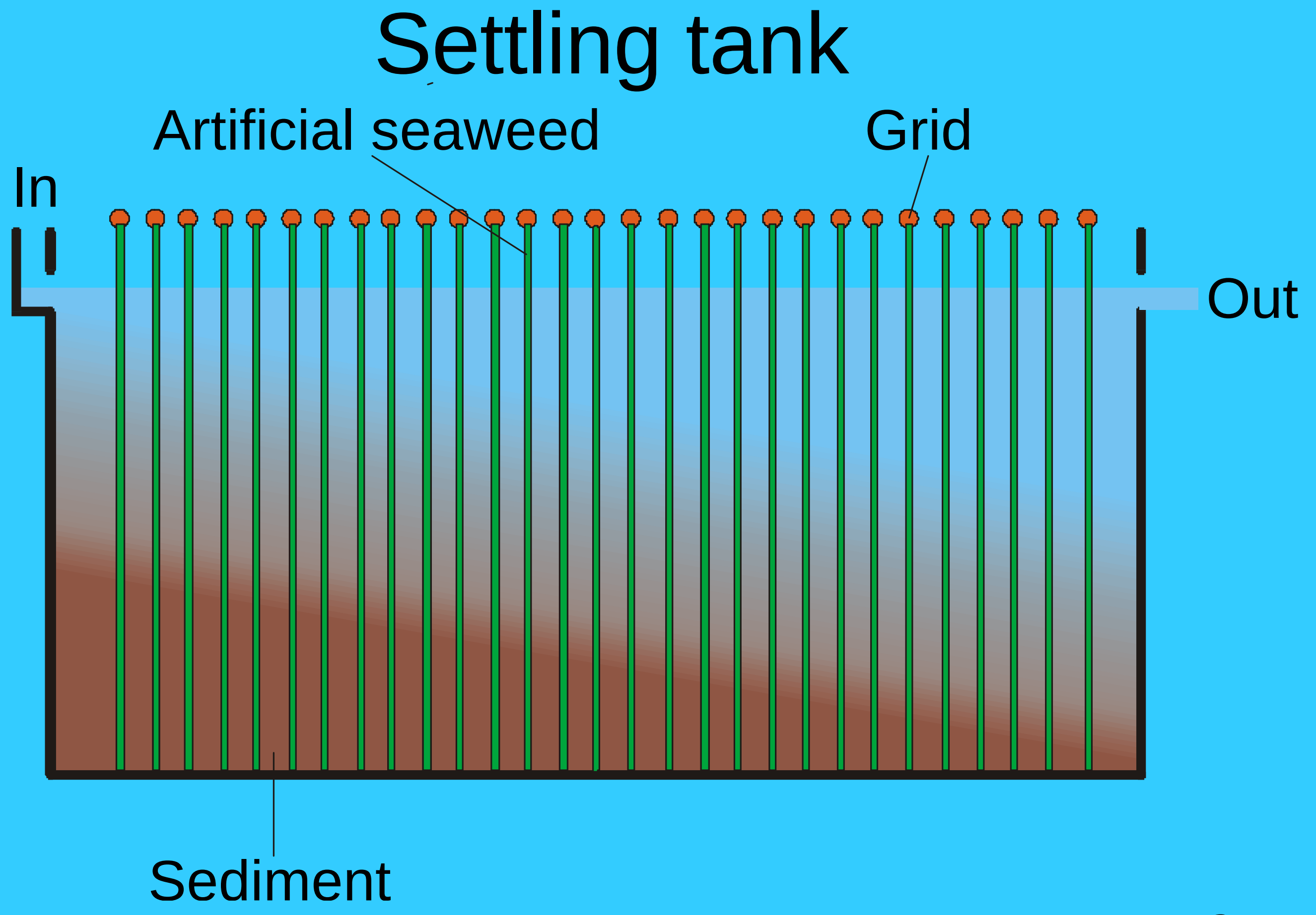
Rofitec 600/2

Solits bv

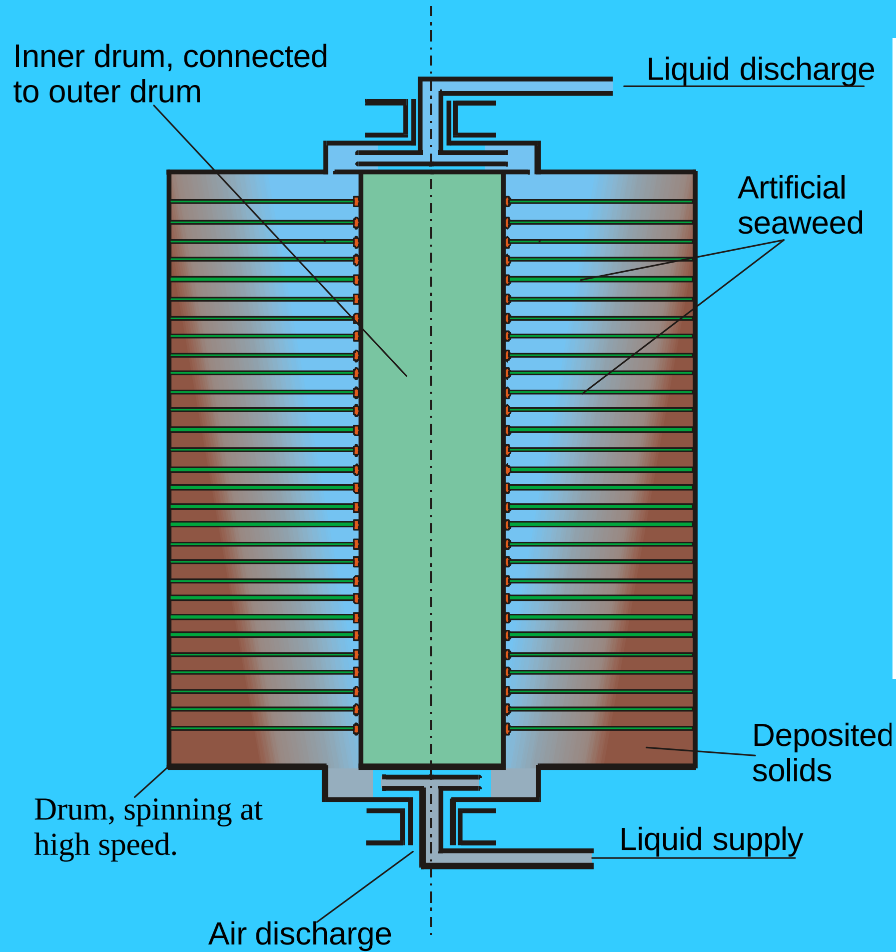
Summary

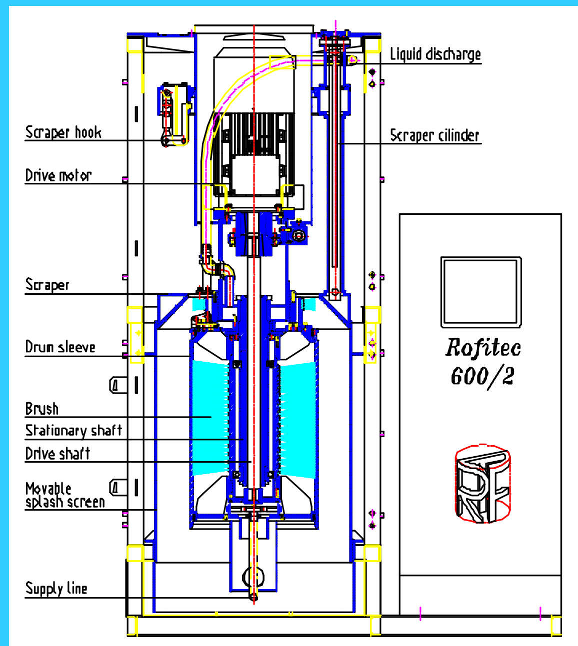
- **Artificial seaweed and gravity.**
- **Rofitec technology.**
- **Brush access without tools.**
- **Rofitec and its applications.**
- **Alternative technologies.**
- **Solits' targets.**
- **Present status.**

Artificial seaweed.



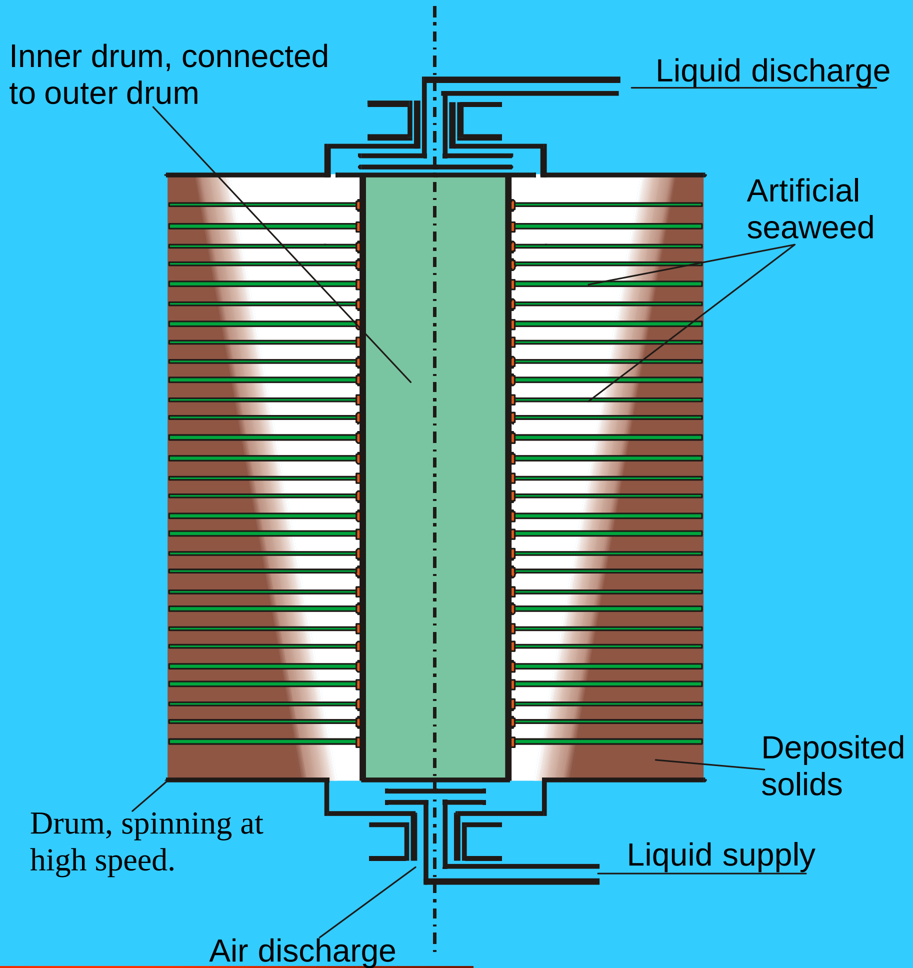
Rofitec technology.

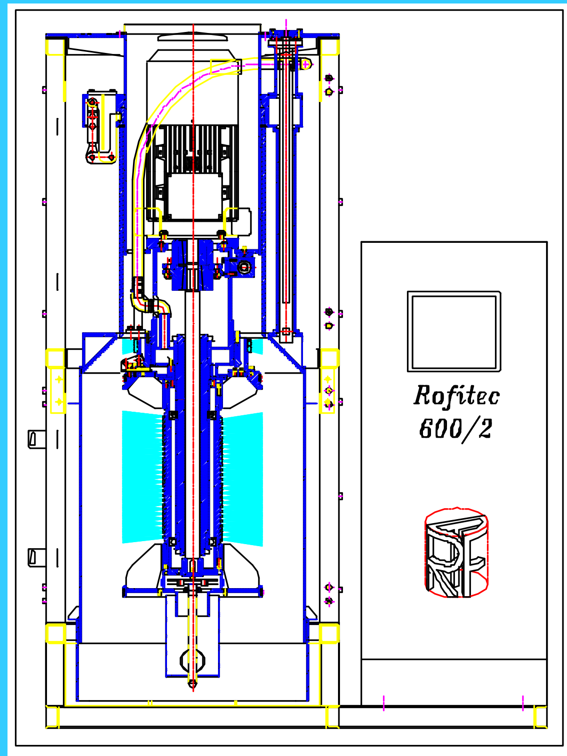




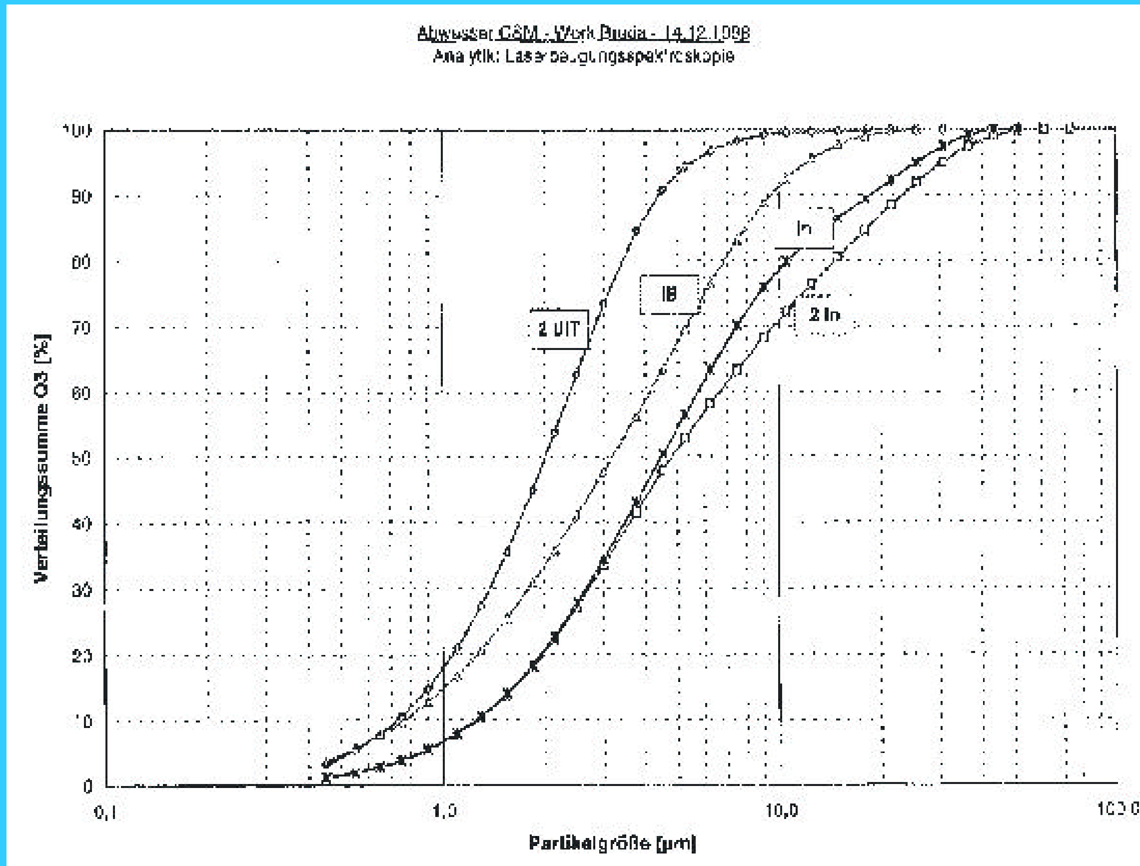
Brush of demo machine.

Rofitec’s discharge system:

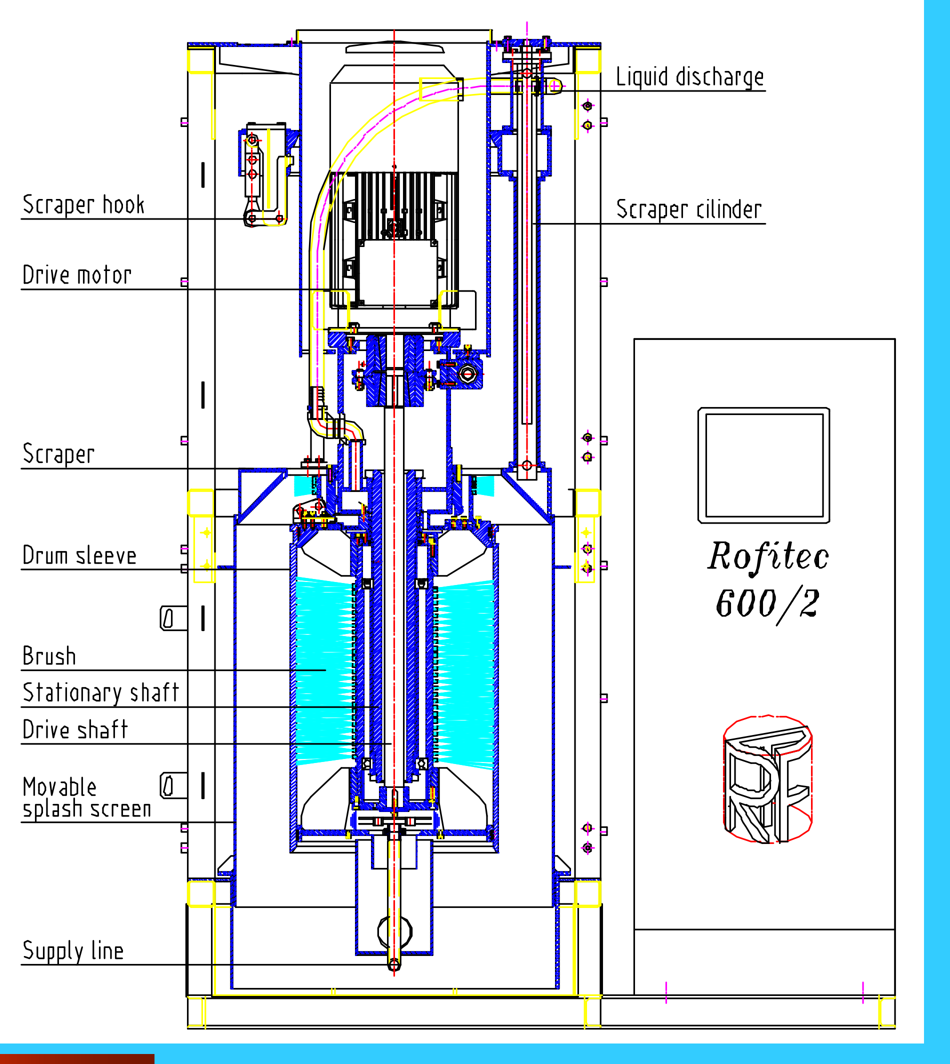




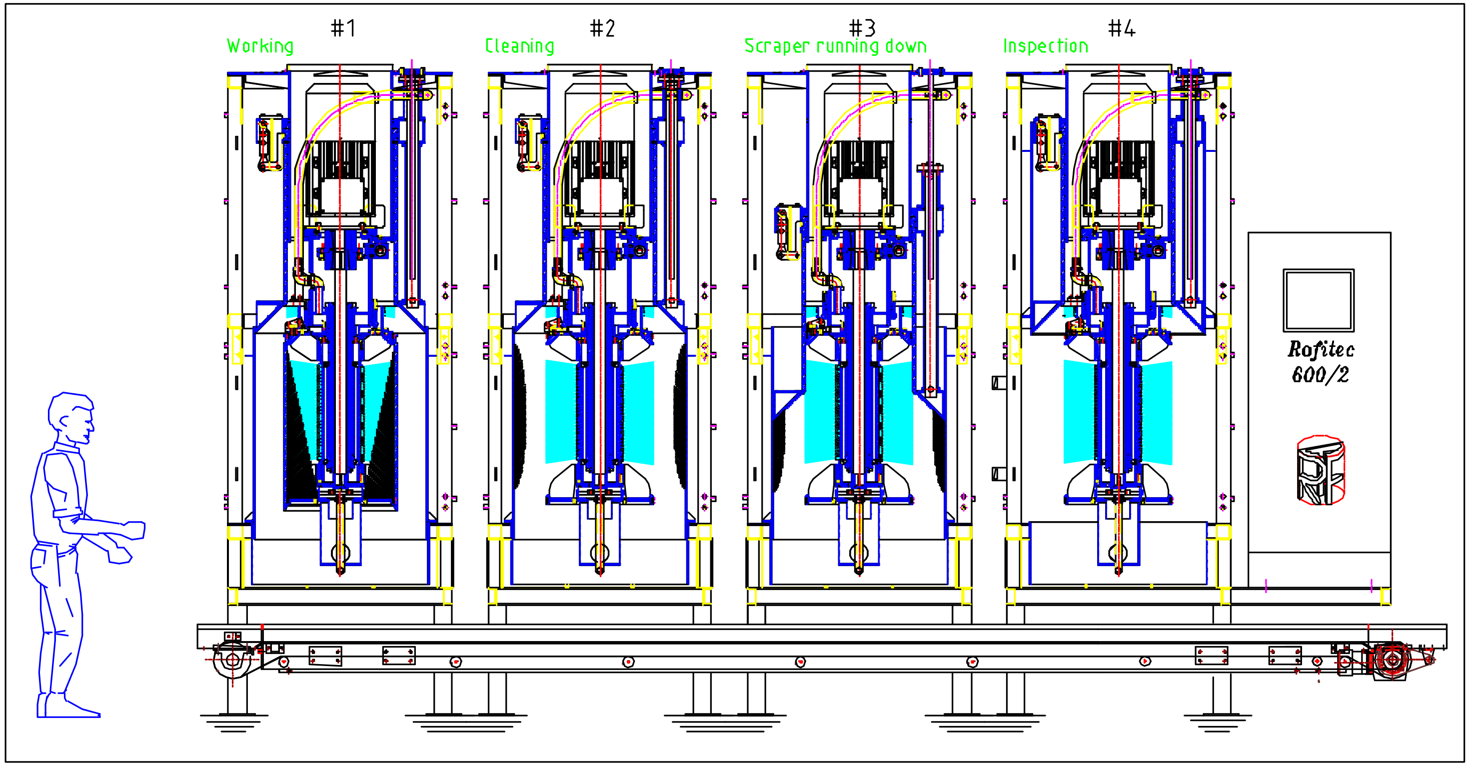
Rofitec’s retention:



Rofitec 600/2.



Brush access without tools



Alternative 1: Separators

- **Advantages Rofitec:**
- **Influent may contain high D.S. content. (up to 10%)**
- **Low energy consumption. (approx. 1,5 kWh/m3)**
- **Low maintenance costs.**
- **Easy to maintain.**

- **Disadvantages Rofitec:**
- **Present flow limited to 15 m3/hr.**
- **No market position.**
- **No track record.**

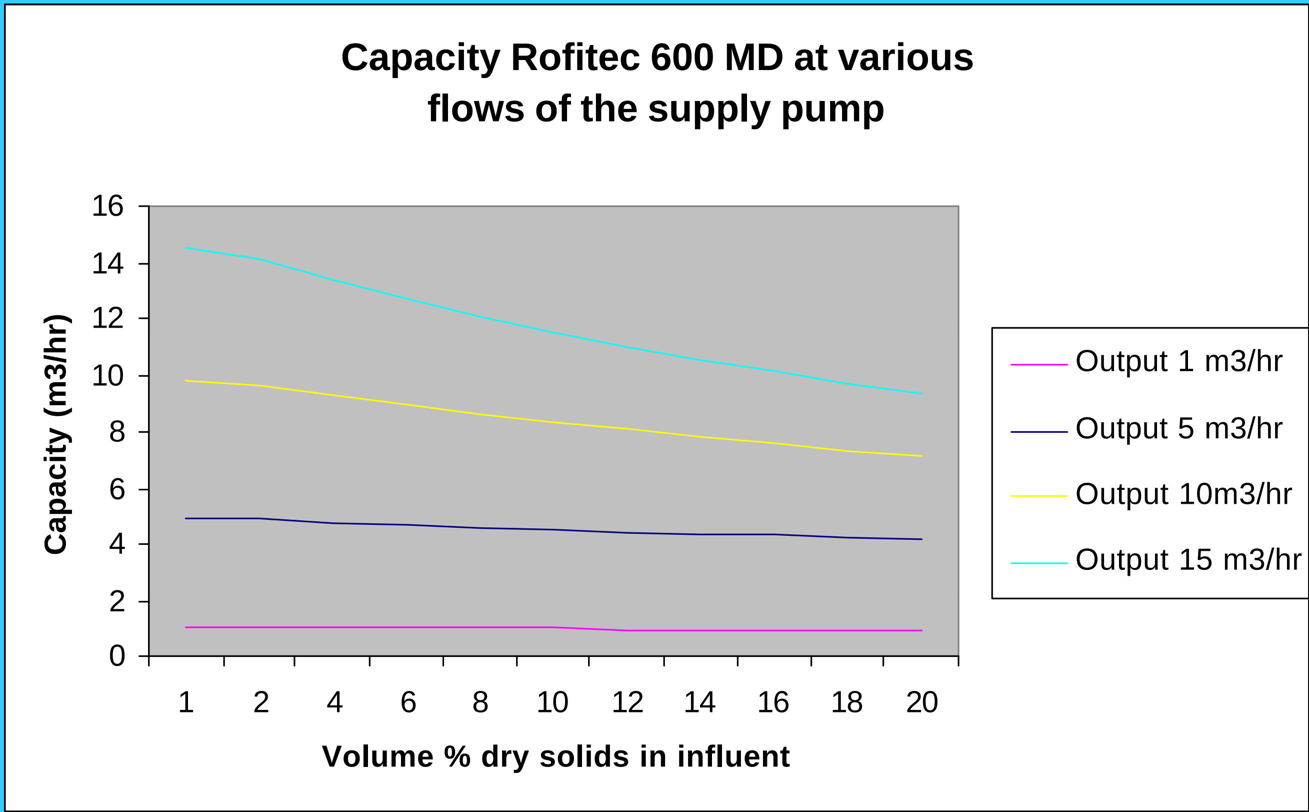
Alternative 2: Decanters

- **Advantages of Rofitec:**
- **High separation efficiency.**
- **Low energy consumption. (approx. 1,5 kWh/m3)**
- **Allows separation of abrasive materials.**
- **Easy to maintain.**

- **Disadvantages of Rofitec:**
- **Batch process.**
- **Present flow limited to 15 m3/hr**
- **No market position.**
- **No track-record.**

Rofitec's capacity

- Drumvolume = 207 litres.
- Start-stop cycle = 4 min.
- S.g. cake = 1,3



Solit's targets:

- To open a market for Rofitec machines.
- To obtain profits for all partners by means of professional marketing in sales and after-sales.

Sales organisation:

Solits bv

- Meat, fish and poultry
- Dairy industry.
- Textile industry.
- Tooling industry.
- Mining industry.
- Marine industry
- Potato, fruit and vegetables processing.
- Paper industry.
- Chemical industry.
- Pharmaceutical ind.
- Petro-chemical ind.
- Etc.

Solits offers to its partners:

- **In technical and geographical market area:**

- **Agreement for exclusive representation**

Or

- **Licence agreement**
  - **Exclusive right to build and to sell.**

- **Technical knowledge plus support**
- **Prototype for testing in the market.**
- **Minimum sales price.**

Solits demands from its partners:

- **Existing position in technical and geographical market area.**
- **The drive to introduce a new product to existing customers.**

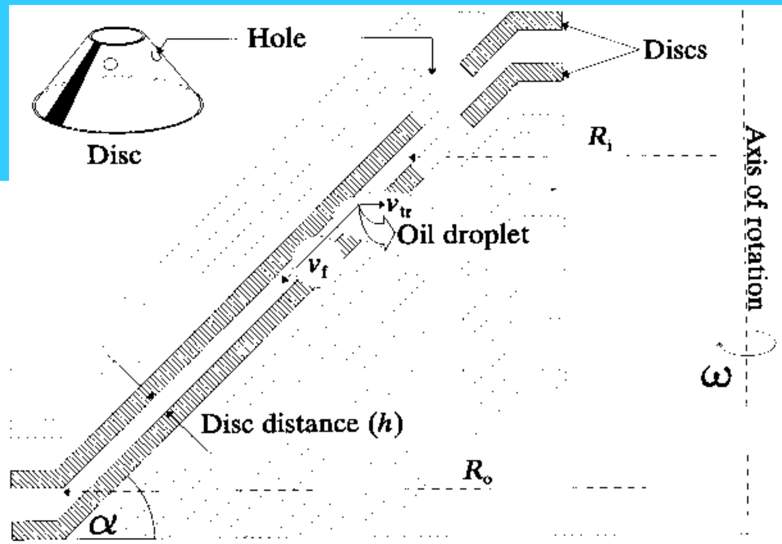
Present status

- System has been tested in many applications.
- First 600/2 machine is under construction, available jan. 02
- Contract meetings with possible partners.
- Solits intents to find more partners.

Summary

- **Artificial seaweed and gravity.**
- **Rofitec technology.**
- **Maintenance without tools.**
- **Rofitec and its applications.**
- **Competitive technologies.**
- **Solits' targets.**
- **Present status.**

Conventional bowl separators



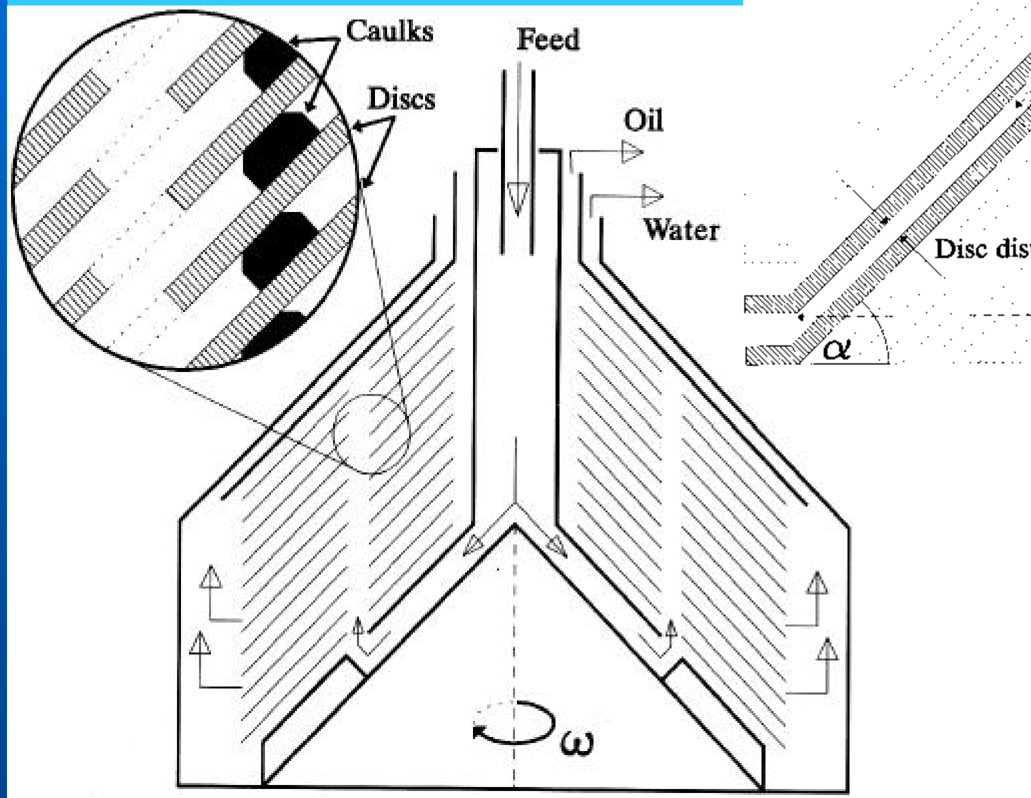


Figure (D-1) The interior of a disc stacked centrifuge.

Curriculum Vitae

Name	**Aad Hoek**
Present function	Acceptance Manager AVR Chemie, Rotterdam
Studies	1964- 1969 Chemistry, Leiden NL 1973- 1976 Proces Technology, NL 1983- 1987 Rubber & Plastics Technology, UK
Experience	**Chemical & reactor development, TNO Delft NL** Exhaust gas afterburners 1968-1973 **Rubber compound development & testing, Hevoet Rubber, NL** Highly speciallised technical rubber compounding, 1973- 1988 **Chief chemist & plant manager, AVR Rotterdam, NL** Start up of newly built plant (HRF), 1988-1989 Plant manager, 1988- 1994 Waste acceptance, 1988- present Procedure developments, 1988- present Legislation, permits etc, 1994- present

Abstract

Aad Hoek
Acceptance Manager AVR Chemie, Rotterdam

**"Waste water Management
(handling, disposal , treatment)"**

Contents

- Operational features of 2 Dutch HRF's (Amsterdam, Rotterdam)
- Geographic position
- Types of maritime waste products involved
- Collection methods
- Storage and handling
- Treatment facilities, capacities
- Expectations, present situation, future developments

Waste Water Management in

Harbour Reception Facilities

as operated by AVR, the Netherlands.

(Handling, disposal, treatment)

By : Aad Hoek, AVR Business Group Industry

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Ladies and gentlemen,

It is my privilege to inform you, in the context of this conference, about the way maritime waste in general, and more particularly maritime waste waters, are being handled in our Harbour Reception Facilities (HRF's), operational during the last 15 years. Because of the complexity of the structures around these HRF's, I will first give some explanations for better understanding.

1. General remarks.

Presence and distribution of HRF's

In the Netherlands there are basically three ways of operational HRF's :

a) In several minor harbours and marina's collection centres have been deployed, mainly for used oils, bilge waters and garbage.
b) Several small companies are carrying out collection of slops by means of slopbarges. Treatment of these stationary and mobile collected wastes is carried out elsewhere.
c) In the two large harbour areas of Rotterdam and Amsterdam however, four reception and treatment facilities have been established for oily and chemical maritime waste
.
Two of those HRF's (one in each of these areas) are operated by AVR, being the largest company involved in hazardous and maritime wastes in the Netherlands.
Because of their geographical position, both HRF's are accessible for sea going ships, inland navigation (barges), off shore activities, fishing vessels etc.

The AVR- context of the HRF's

The two HRF's have been founded in the eighties according to Marpol- obligations as extensions of already operational companies concerned with industrial cleaning and services, collection and handling of hazardous waste and some specialised services like catalyst- handling and inspections.

In the late nineties, AVR as operator of rotary kilns for hazardous waste acquired these HRF's to expand the scope of activities to be able to offer a modular approach in which all waste related activities are incorporated.

By doing so it also has become possible to integrate storage, handling, treatment of maritime wastes in already operational structures, enabling maritime wastes to be handled in combination with idententical industrial waste streams. Especially the logistic aspects thus become more economical.
Furthermore in- company available waste treatment- methods are easily accessible within one administrative system which is more and more becoming important as legislation is putting on stricter demands on transparency in waste handling.
Also, every activity can, whenever necessary be supported by one of the other available activities in easy and integrated working methods, using existing know how, personnel and equipment.

The present slide gives an impression of the AVR- sites in the Rotterdam industry and harbour area Europoort. In the foreground the HRF, halfway to the sea (background) the AVR's incineration site.

Scope of activities of AVR Maritime

To illustrate this subject, I will briefly describe the Rotterdam situation .
At the same location a terminal and a waste treatment centre are permanently linked by a number of pipelines for waste streams, hot water and several commodities.
Both are linked to the same automated administration system and use the same utilities and internal services.

2. The HRF's front side, ship- shore interactions (Rotterdam terminal).

The terminal- activities

The terminal offers a variety of waste related possibilities and services towards the maritime sector

: Tank cleaning and waste collection :
- at the terminal
- by means of slop barges
- road tanker or vacuum truck
- at (un)loading sites (terminal, shipyards etc)

Furthermore non waste related services are provided from the terminal jetties i.e.:

Transhipment	- from deep sea to coastal vessels - from deep sea and coastal vessels to inland barges - and vice versa
Delivery of supplies	- hot and cold water - potable water - distilled water - hot or cold nitrogen - liquefied gases (ingassing)

Other, related activities

It has proven to be advantageous to operate a number of related activities such as

- Oil spill removals (co-operation with Port Authority)
- Preventive measures such as application of oil booms (co-operation with Port Authority)
- Harbour cleaning (co-operation with port Authority)
- Transport of domestic waste (on behalf of sister companies)
- Transport of waste originated products from Treatment Plant (i.e. recovered oil)
- Assistance at calamities on ships and along quay sides.
- Consultancy to engineering firms, authorities, customers

Again, the availability ofso many in- company facilities and techniques on logistics, handling and equipment is facilitating these operations.
A centralised commercial approach of all relevant market- segments is helpful in offering the right combination of services in each occurring event.

3. The HRF's back side (waste treatment)

The Waste Treatment Plant (Rotterdam)

A wide range of waste- types can be handled.
For that reason also a wide range of waste treatment methods are available and are being used, wherever applicable for maritime as well as for industrial waste. Wherever possible, depending on composition, no distinction is made between these streams in treatment methods.

The largest streams (by volume) are waste waters (prewashes, washings), oil sludges and chemical sludges

The available equipment and techniques are:
- storage capacity for liquids , sludges and solids of several specifications, up to 16.000 cbm total
- physicochemical and biological water treatment; hydraulic capacity 800.000 cbm/a, nominal capacity 300.000 cbm/a
- decanters and centrifuges for phase separations
- pre-treatments for incineration, recovery and recycling
- drum handling and -shredding
- incineration of gases (odour and emission control on ships)
- pre-treatment of waste- batches to enhance processability or to meet specifications
- dispatch of biologically non- treatable streams to nearby AVR- incineration plant

Waste water treatment

Waste products, arriving at the Treatment Plant are screened and/ or examined to select the most effective (licensed) way of treatment. For the complete palette of hazardous wastes some 100 possible treatment routes are available.

Some of these routes involve the treatment of wastewaters. From maritime origin this could be prewashes, washings, ballasts, bilge waters, grey and black waters. Route (method) selection occurs by:

- Use of expert list for well defined, known products. Intake can take place around the clock without time consuming analyses. These streams are sampled, but control- analysis is done afterwards.
- Laboratory control to assess properties and possibilities of unknown or ill- defined products and slops. This control can involve bio-simulation for destination of efficiency of biological break down, influence on active sludge behaviour etc. Such test procedures, depending on the aspects to be checked take 1 hour to 2 days. In the latter case, the batch concerned is temporarily stored separately, waiting for the test result.

Waste water treatment may involve :

1. Direct intake in reception tanks is made for oil- respectively chemically polluted waters. This distinction is made to facilitate separate recovery of oil and chemicals floating on top in these tanks, for subsequent processing. Direct intake goes for waters with relatively low pollution contents.
   The treatment process, after sufficient settlement of emulsified products, involves flocculation – flotation (DAF), carefully operated buffering to minimise fluctuations of properties, and the final biological treatment in an aerated, continuous flow bio-reactor. This reactor contains, next to activated sludge, as an extra safety measure a quantity of powdered activated carbon for adsorption of minor quantities of toxic or non- biodegradable compounds, thus improving the discharge quality.

2. When concentrations of pollution are higher, separate intake is preferred to be able to avoid concentration- peaks in the bioreactor. From these separate tanks, waters are “injected” into the main stream to obtain smooth and small changes in property- patterns.

3. Waste waters containing toxic or non- biodegradable compounds or compound that are outside the scope of licences (for instance chlorinated pesticides, chlorinated solvents, mercury, other heavy metals are limited at different levels) cannot and may not be treated in the above mentioned manner.
   If possible (assessed in the Laboratory tests) a pre-treatment is performed to improve properties or to remove obstructing compounds to within prescribed specifications. There is quite a large number of pre-treatment possibilities

available i.e. extractions, precipitation, filtration (high-pressure filters, ultrafiltration), sedimentation, demulsification, phase separation, thermal treatments, adsorption etc.
If successfully performed, the treated batch can be introduced through one of the above mentioned routes.

4. If pre-treatment is not possible or not (sufficiently) effective, the batch at hand has to be destroyed by incineration and is transported to the nearby AVR incineration-site.

5. An exemption is made for black water. These streams are directly transported to nearby communal watertreatment sites. We consider them better equipped to cope with sanitary risks involved.

Quality assurance and improvement

To ascertain desired levels of quality and to be able to face rather strict demands from more and more complex legislation and rules, a number of measures and means have been introduced.

ISO- certificates
All AVR BGI sites possess certificates according to ISO 9002 and ISO 14001.

Compliance
At this moment a large compliance program is being developed and implemented to even more improve on quality assurance. One of the reasons to do so, is the increasing degree of difficulty in complex legislation, which is leaning quite hard on our type of business.

Controls and analyses
In all stages involved in the process from acquisition of waste streams up to collection, intake, storage, processing and discharge, much effort is put into control measurements. Most of this is performed by our own Laboratory, giving feed back to

- Sales (acquisition and invoice procedures),
- Acceptance (choice of treatment routes and compliance to licences),
- Operations (control of stocks, process control, discharge control)
- and to local/ regional authorities (licences, environmental control).

Client programs.
In order to improve on assessment and control of incoming streams (AVR interest), combined with improvement on treatment costs (client interest), AVR organises client programs.
Since several years shipping companies have been invited to send Captains and First Mates to join these sessions. The largest companies right now are preparing for second rounds.
Goals are to create basic insight in waste treatment methods and the criteria on which methods are chosen, awareness of costs and differences in costs depending

on chosen methods, understanding of how costs can be influenced onboard the ships, insight in rules and legislation applicable to onshore sites. Is has been proven that just by lack of knowledge on these subjects, in many cases procedures onboard ships lead to considerable, avoidable costs.
Examples of avoidable mismanagement:

- Combining (pre)washes of different treatment routes
- Unnecessarily storing products separately, using limited space inefficiently
- Use of wrong solvents, detergents, and emulsifiers causing extra treatment costs.
- Misinterpretation of Marpol Annexes

Also specific shipping- related problem are explained, creating more understanding on the side of the HRF- personnel.

By sharing knowledge of common interest and better mutual understanding, it has been proven that waste related costs and efforts could be improved for all parties involved.

4. Final remarks

Questions and solutions

For present and future some short remarks and questions can be made on several interrelated aspects. Not in all cases the answers can or should be be given by HRF's, but should come from one of the many parties involved and most certainly present at this conference.

Technical

- Development of cheaper treatment methods for non-biodegradable waters is needed to fill up the tariff gap between biological treatment and incineration.
- Maritime waste streams tend to become more difficult by increasing concentrations, larger number of products, waste management and processing onboard ships.

Environmental

- Legislation and rules lean hard on waste related activities. Therefore much effort has to be put in internal education of personnel. Awareness and compliance programs for all organisation levels are essential to continuously meet the demands.
- Co-operation programs with customers offer mutual advantages.

Economics

- It has been established that a stand alone HRF, fully dependable on maritime waste streams is not profitable (in Dutch circumstances though). Integration of HRF's in operational industrial waste collection and treatment activities is useful in many ways and should be favoured.
- Nowadays, operating in market mechanism with a relative shortage of maritime waste streams is only feasible with sufficient side- activities.

- Improvement of amounts of waste waters is beyond the reach of HRF's (see hereafter)

Political

In the Dutch situation (fully implemented HRF's and provisions) the expectations about the amount of maritime wastes have not yet been realised. In our perception this is mainly caused by

- Large differences inapproach between virtually comparable countries
- lack of international (e.g. European) uniformity on rules and enforcement of rules
- differences in availability of HRF's
- lack of waste tracking systems

This causes misunderstandings and even evasive actions with maritime waste in search of the cheapest available option.
For the sake of environment, international shipping as well as the profitability of HRF's a more consistent international approach is very desirable.

With this I hope to have given you, from the practice of operational HRF's, a bit of insight in our business.

Harbour Reception Facilities

Waste Water Management

AVR

DUTCH HRF 'S

- > 40 STATIONARY COLLECTION SITES (OIL)
- SEVERAL SLOP BARGE COMPANIES
- 4 LARGE HRF's , OIL & CHEMICAL, COLLECTION & TREATMENT

- 2 OF THOSE AVR- OPERATED

AVR BG INDUSTRY

MAIN ACTIVITIES

- INCINERATION BY ROTARY KILLNS
- METAL RECOVERY
- PRODUCTION OF ELECTRICITY
- PRODUCTION OF DESTILLED WATER
- INDUSTRIAL CLEANING & SERVICES
- MARITIME & INDUSTRIAL WASTE HANDLING
- WASTE WATER TREATMANT
- RECOVERY OF OIL & SEC. FUELS
- PROTECTED DEPOSITS (3 CATEGORIES)
- ON SITE WASTE MANAGEMANT & CONSULTANCY

EUROPOORT AREA

ROTTERDAM

HRF

AVR- Maritime

+

AVR Waste Treatment Plant

=

Harbour Reception Facility

AVR-MARITIME

ROTTERDAM HRF SITE

WHAT- WHERE- HOW

SLOP COLLECTION SERVICES & SHIP CLEANING

- at AVR terminal
- by slop barges
- by road tanker or vacuum truck
- at (un)loading sites
- at shipyards

TERMINAL

- SMALL JETTY
  - 4x 100 m at 5 m DRAUGHT
- LARGE JETTY
  - 1x 240 m at 15 m DRAUGHT and
  - 2x 100 m at 10 m DRAUGHT

AVR-MARITIME

AVR BG INDUSTRY

SLOP BARGES

- 1 C- TYPE (CHEMICALS)
  2000 MT
- 2 N- OPEN TYPE (OIL/ WATER)
  40 / 1450 MT
- 8 N- OPEN TYPE (OIL/ WATER)
  40 TO 320 MT

AVR-MARITIEM

AVR-Industrie

ROLLING EQUIPMENT

- VACUUM TRUCKS
- TRANSPORTERS
- HIGH PRESSURE, 2000 BAR
- COMBI UNITS
- CONTAINER TRANSPORTERS
- AUXILLIAIRY EQUIPMENT

AVR-MARITIME

AVR BG INDUSTRY

SPIN OFF
TERMINAL ACTIVITIES

- Transhipment (Liquids & Gasses)
  Deep sea - Coastal - Inland navigation
- Supply of commodities
  Water, steam, air, nitrogen, fuel
- Repairs, storing, pilots, lay by

OTHER SPIN OFFS

- CONSULTANCY
  - Global selling of the HRF-concept
  - International 'Trouble-shooting', support on operational expertise
  - Customer services on waste handling onboard ships

OTHER MARITIME SERVICES

- Oil spill removal
- Application of oil booms
- Harbour cleaning (co-operation with port Authority)
- Assistance at calamities on ships and along quay sides
- Transport of domestic waste (on behalf of sister companies)
- Transport of waste originated products from Treatment Plant (i.e. recovered oil)

AVR-MARITIME

OIL FIGHTING VESSEL

AVR-MARITIME

PREVENTION

AVR-MARITIME

“GARBAGE FISHING “

AVR-MARITIME

TRANSPORT OF WASTE

WASTE TREATMENT PLANT

- INDUSTRIAL & MARITIME WASTE
- SOLIDS, LIQUIDS, SLUDGES
- OILY & CHEMICAL
- ODOUR & VAPOURS
- DRUMS & CONTAINERS

WASTE TREATMENT PLANT

- PHYSICO CHEMICAL & BIOLOGICAL WATER TREATMENT
- PRE TREATMENTS
- INCINERATION (VAPOUR/ ODOUR)
- PHASE SEPARATION
- DRUM SHREDDING
- FILTRATIONS
- PREPARATION FOR EXTERNAL TREATMENTS

TYPES OF WATER RECEIVED

PREWASHES

WASHINGS

SLOPS

WATER FROM PRETREATMENTS

BIOLOGICAL WATER TREATMENT

CAPACITY : 800.000 T/A hydraulic
300.000 T/A nominal

DISSOLVED AIR FLOTATION
+
AERATED ACTIVATED SLUDGE

CONTINUOS FLOW REACTOR

> 99.5 % CONVERSION ON BOD
93 to 97 % CONVERSION ON COD

WASTE WATER ROUTES

- EXPERT LIST : DIRECT INTAKE
- NEW/ UNKNOWN PRODUCTS : ANALYSIS
- HIGHLY CONCENTRATED : BIOLOGICAL BY "INJECTION"
- UNKNOWN : BIOLOGICAL OR INCINERATION
- OFF SPEC: SOMETIMES ENHANCED BY PRE- TREATMENT
- FORBIDDEN OR RULED OUT: INCINERATION

NON BIODEGRADABLE WATERS

- SELECTED BY OWN SIMULATION TESTS OR LICENCES
- SOMETIMES ENHANCEBLE BY PRETREATMENTS
- IF NOT : REMOVAL BY INCINERATION (AVR- KILNS)

GUARDING & IMPROVINGQUALITY

- LOTS OF ANALYSES ON INPUT, STORAGE, PROCES AND OUTPUT BY OWN LABORATORY
- EXPERT PRODUCT LIST
- SCREENING OF NEW/ UNKNOWN PRODUCTS
- ISO 9002 AND ISO 14001
- COMPLIANCE PROJECTS
- CUSTOMER EDUCATION PROJECTS

QUESTIONS (& SOLUTIONS ?)

- TECHNICAL
- JUDICIAL
- ECONOMICAL
- POLITICAL

QUESTIONS (& SOLUTIONS ?)

TECHNICAL

- CHEAP NEW TECHNIQUES FOR NON BIODEGRADABLE PRODUCTS
- MARITIME WASTES DECREASE IN PROCESSABILITY

QUESTIONS (& SOLUTIONS ?)

JUDICIAL

- LICENCE DEMANDS TEND BECOME STRICTER & UNBALANCED
- AWARENESS OF REGULATIONS
- EUROPEAN ENVIRONMENTAL RULES?

QUESTIONS (& SOLUTIONS ?)

- ECONOMICS

- STAND ALONE HRF ECONOMICALLY NOT PROFITABLE
- SURROUNDING, DERIVED/ LINKED ACTIVITIES ARE ESSENTIAL
- STILL TOO MUCH CAPACITY (NL)

QUESTIONS (& SOLUTIONS ?)

POLITICAL

- BIASSED COMPETITION BY DIFFERENT LAWS AND RULES
- EUROPEAN UNIFORMITY OF REGULATIONS NEEDED
- UNIFORM ENFORCEMENT TO AVOID DISADVANTAGES FOR BETTER BEHAVING HARBOURS
- MUCH WASTE NOW NOT TO HRF'S

AVR

AVR makes something out of it

AVR

AVR makes something out of it

End

Eule & Partners

International Consulting S.P.R.L.

Maritime Conferences

• The Maritime Environment •

”Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports”

Supplement

Summary of the Conference on "Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports" in Bremerhaven, Germany on 12th to 14th September 2001

The International Conference on "Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports" was held in the Best Western Hotel Naber in Bremerhaven, Germany on 12th to 14th September 2001.

The Conference had been initiated and was organized by Eule & Partners International Consulting SPRL, Tervuren, Belgium and Schortens, Germany.

The Conference was overshadowed by the terrible acts of terrorism in the United States. All of the participants expressed their sympathy and showed their solidarity with the American People

The Conference was conducted under the patronage of the Senator for Economy and Ports of the Hanse City of Bremen. It was sponsored by DEERBERG-SYSTEMS in Oldenburg, Germany and the US Navy Office of Naval Research International Field Office in London, UK. The City of Bremerhaven supported the conference.

Bremerhaven is one of the major German seaports belonging to the Hanse City of Bremen. All different trades of the maritime industry are located there, whether it is the Shipping Industry with several shipping lines, a major shipyard, or the fishery industry. The City of Bremerhaven offered a tour of the city and its port in the afternoon of the first day of the conference.

Bremen and Bremerhaven for many years have undertaken major efforts in the area of environmental protection of the ports, sea and shores.

The Senator of Economy and Ports of the Hanse City of Bremen hosted a reception aboard the Sailing Vessel "Seute Deern" offering opportunities for business and social contacts with the conference participants.

In the world of maritime application of waste management systems DEERBERG-SYSTEMS is a well known company and the world-wide leading supplier for Total Waste Management Systems for the Cruise Line Industry. DEERBERG-SYSTEMS now has been supplying over 115 systems to large passenger vessels. Mr. Deerberg hosted a dinner on the second evening. The guest of honour was Mr. Werner Lueken, the Managing Director of the Lloyd's Werft in Bremerhaven.

The US Navy Office of Naval Research International Field Office is committed to fostering and facilitating collaboration in Science, Technology, Research and Development between the United States and their professional counterparts in Europe, Africa and the Middle East. The US Navy Office of Naval Research International Field Office is linked with international scientists and engineers through conferences, workshops, visits and personal research to identify key

opportunities in Science & Technology, to assess Science & Technology activities and accomplishments and to exchange information and ideas in areas of mutual interest.
The US Navy Office of Naval Research International Field Office is based in London.

The Conference objectives were:

- To provide of a forum for representatives from industry, ship owners, academia, governments, maritime and harbour authorities and shipyards for discussion and exchange of information on policies, trends and development of regulations for the treatment of ballast water, waste water and sewage on ships and in ports.
- To discuss the management aspects related to waste water and ballast water treatment.
- To present and discuss technologies and equipment for the treatment of black, grey and oily water as well as ballast water and sewage generated on board of ships.
- To present and discuss advanced treatment technologies, future research and adaptation of current and future technologies for ship systems and
- To make recommendations for latest technology applications on ships and in ports as well as for policies and international collaboration.

DEERBERG-SYSTEMS from Germany, Zenon from the United States, BETECH from Belgium and Petrol Rem Inc. from the United States exhibited their products during the conference.

Nearly 100 Experts from 14 different Nations (Belgium, Canada, Denmark, Finland, France, Germany, Israel, Italy, Monaco, The Netherlands, Norway, Sweden, the United Kingdom and the United States) attended the conference. They represented the whole range of interested groups in this field, i.e. Cruise Lines and Shipping Industry, Shipyards, Navies, System Engineering Companies, Equipment Manufacturers and Regulation Authorities.

The Conference was organized in two Sessions:

<u>Session 1</u> – Ballast Water – Session Chairman Dr. Matthias Voigt, Environmental Consultant, Germany

<u>Session 2</u> – Waste Water and Sewage Treatment – Session Chairman, Mr. John Klie, Zenon Environmental Inc., Canada

The papers presented covered the whole range of concepts, technologies, equipment and systems for the treatment of ballast water as well as the treatment of waste water, i.e. black water, gray water, oily water and sewage. They were oriented mainly towards applications for shipboard installation and operation.

An increasingly important environmental problem is the exchange or treatment of ships ballast water in order to avoid foreign species to be imported to other maritime regions, where they may become harmful to the natural or industrial environment.
The methods for exchange of ballast water were presented and discussed and a Ballast Water Management Plan was introduced. Still many of the participants believe that ballast water exchange

is technically difficult, will not sufficiently be able to treat the sediments in the ballast water tanks and may still be too dangerous to the ship's stability.
Slowly concepts for chemical treatment of the large amount of ballast water are emerging aiming at treatment at the intake in one port or sea area and also during the pumping overboard in another area. A combination with a physical treatment process, such as filtration and UV-radiation appears to become a viable solution.
Overall it was recognized that more effort needs to be invested to cope with the problem.

Over the last period since the conference on waste water treatment technologies in Genoa, Italy in March 2000 technology has matured. Still the MARPOL Annex IV has not been implemented, although it looks like Norway and the Netherlands are now ready to ratify, which would reach the 50% of the world tonnage figure necessary to set Annex IV into force. In the meantime several coastal regions have established their own more restrictive regulations and standards for waste water discharge. In view of a more restrictive policy for compliance the cruise lines in particular have set their own pro-active goals with regard to system in order to achieve very clean effluents from their ships.

Regarding waste water and sewage treatment we are at a stage where combined membrane/bio reactor systems have become the recognized technological solution to cope with the large amounts of waste water to be treated aboard ships.
Manufacturers are improving their systems as they gain experience with their operation and new materials become available.
Also practical operation aboard ships show that zero-maintenance and hands-off operations have to be improved in order to maintain reliable continuous efficiency.
An area for continued research and development is the ever-increasing amount of waste water to be treated daily aboard large passenger vessels which are growing in size, number of crew and passengers. Again, the answer appears to be lying in a combination of different technologies.
The reuse of treated waste water as technical water, e.g. for flushing or laundry has become more common, but it requires that the ships water and piping system has to be designed for this purpose in its construction phase.
Two related issues with waste water treatment are bilge water treatment and the treatment of sludge resulting from waste water treatment.
Bilge water treatment seems to be well in hand and even more restrictive standards for remaining oily particles will be met by modern mechanical centrifugal as well as bio-reactor/membrane systems.
The increasing amount of sludge and the way it needs to be handled requires further development or system solutions, e.g. incineration.
Part of most waste water treatment systems is a stage of pre-treatment including the separation of solids from the water. There are new filter and separation systems currently being evaluated.

Overall the conference provided lively and interesting discussions amongst the participating experts. The conference participants have learned more about the products and capabilities of the manufacturers as well as the requirements of the customers, especially the Cruise Industry.

The discussions clearly showed that the participants in the conference were aware of the international and regional ecological demands in the maritime environment and searched for the best technology to be compliant with the environmental requirements.

The exhibitions by BETECH, DEERBERG-SYSTEMS, Zenon and Petrol Rem Inc. have helped visualizing the systems, technologies and products addressed during the conference.

Organizationally and socially the conference worked very well. The Best Western Hotel Naber in Bremerhaven offered excellent conference facilities and support.

The participants used the conference extensively to conduct business discussions.

The social events, the luncheons, the tour of the city and the port off Bremerhaven, the reception hosted by the Senator for Economics and Ports of the Hanse City of Bremen and the dinner hosted by DEERBERG-SYSTEMS offered many additional opportunities for discussions amongst the delegates.

In summary the conference was received very well by the Participants, who expressed their desire, to participate in future conferences in the area of environmental technologies for ships and other maritime applications.

Klaus D. Eule
Conference Organizer

Participants in the Conference
"Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports

September, 12th - 14th 2001, Bremerhaven, Germany

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Senator für Wirtschaft und Häfen	**Lampe**	Dr.	Carola	Zweite Schlachtpforte 3	28195	Bremen	+49 421 361 6860	+49 421 361-10097
T&S Transport & Service GmbH	**Wibel**		Carsten - S.	Geo-Plate-Str. 1	27568	Bremerhaven	+49 471 48729	+49 471 487455
Taprogge Gesellschaft mbH	**Trostmann**	Dipl.Ing.	Dirk	Schliemannstr. 2-14	58300	Wetter	+49 2335 762 131	+49 2335 762 211
Thyssen Nordseewerke	**Oettel**		Rüdiger	Zum Zungenkai 1	26725	Emden	+49 4921 852092	+49 4921 852945
ttz-Bremerhaven	**Aslan**	Dipl.Ing.	Filiz	An der Karlstadt 6	27568	Bremerhaven	+49 471 9448 714	+49 471 9448 722
ttz-Bremerhaven	**Fernandez**	Dipl.Ing	Dolores	An der Karlstadt 6	27568	Bremerhaven	+49 471 9448 707	+49 471 9448 722
Umweltbundesamt	**Brenk**	Dipl.Ing.	Volker	Bismarkplatz 1	14193	Berlin		
VA TECH WABAG GmbH	**Richter**	Dipl.Ing.	Steffen	Lise-Meitner-Straße 4a	40878	Ratingen	+49 2102 45270	+49 2102 452799
Virtus GmbH	**Klaeke**		Rolf	Kleines Wegfahrels 10	21756	Osten	+49 4776 8383	+49 4776 838484
Westfalia Separator Mineraloil Systems	**Mackel**	Dipl. Ing.	Jürgen	Werner-Habig-Straße 1	59302	Oelde	+49 2522 772707	+49 2522 7732707
Westfalia Separator Mineraloil Systems	**Witte**	Dr. Ing.	Klaus-Rainer	Werner-Habig-Straße 1	59302	Oelde	+49 2522 772979	+49 2522 7732979

Nation: **FI**

Evac Oy	**Näkki**		Juha	Purotie 1	00380	Helsinki	+358 9 50676202	+358 9 50676333

Company	Name	Titel	First Name	Address			Telephone	Telefax
Evac Oy	**Naski**		Tommi	Purotie 1	00380	Helsinki	+358 9 506 761	+358 9 5067 6333
Evac Oy	**Nylund**		Ari	Purotie 1	00380	Helsinki	+358 9 50676202	+358 9 50676333
Kvaener Masa - Yards Inc.	**Mattsson**		Roland	PO Box 132	00151	Helsinki	+358 9 1942868	+358 9 194 2354 051
					Nation: **FR**			
DCN ING/CN	**Bathany**		Daniel	BP 26	29240	Brest Naval	+33 2 98 22 51 20	+33 2 98 22 69 99
DGA/SPN	**Matez**		Richard	8 Boulevard Victor	00303	Paris Armées	+33 1 40 59 10 68	+33 1 40 59 23 91
Pall Rochem Marine	**Suidureau**		Jean	3 Rue Des Gaudines	78175	Saint Germain En Laye	+33 1 30 61 38 31	+33 1 30 61 57 82
					Nation: **IL**			
Arkal Water Technologies	**Sorek**		Danny		15135	Bet Zera, Jordan Valley	+972 4677 5140	+972 4677 5476
					Nation: **IT**			
Fincantieri C.N.I. S.p.A.	**Pagano**		Gio Batta	Via Cipro,11	16129	Genova	+39 0105995271	+39 010-5995379
Fincantieri S.p.a.	**Fabro**		Michele	Paseggio S. Andrea 6/a	34123	Trieste	+39 040 319 3859	+39 040 319 3720
Fincantieri S.p.a.	**Guiffrida**		Massimiliano	Paseggio S. Andrea 6/a	34123	Trieste	+39 040 319 3663	+39 040 319 3682
Fincantieri-Monfalcone Shipyard	**Farina**		Lucio	Piazzale Callisto Cosulich	34074	Monfalcone	+39 0481 492 274	+39 481 492 218
I.S.I.R. S.p.A	**Antonelli**		Enriko	Via Luigi Canepa, 16R	16165	Genoa	+39 010 841850	+39 010 803307
					Nation: **MC**			
Hepburn Bio Ship Care	**Hepburn**		Margaret	Palais de la Scala, Ave. 1 Henry Dunant	98000	Monaco	+377 977 057 50	+377 977 057 49
					Nation: **NL**			
AVR - Maritiem B.V.	**Hoek**		Aad	Oude Maasweg	3197 KJ	Rotterdam-Botlek	+31 181 273 220	+31 181 273 202
Confederation of European Shipmasters' Associations	**Van Wijnen**	Capt.	Fredrik J.	Deltsestraat 9c	3013 AB	Rotterdam	+31 10 240 0592	+31 10 240 0596
GreenShip b.v.	**De Vries**		Marten	P.o. box 7037	9701 JA	Groningen	+31 50 589 13 34	+31 50 313 10 47

Company	Name	Titel	First Name	Address			Telephone	Telefax
IWACO B.V	**Sprong-Wijnreder**		Franca	Hoofdweg 490	3067 GK	Rotterdam	+31 10 2865429	+31 10 2201005
IWACO B.V	**van Nierkerk**		Han	PO Box 94241	1090 GE	Amsterdam	+31 020-5697777	+31 020-5697766
Ministry of Transport & Public Works	**Bolt**		Klaas Jan	P.O. Box 20940	2500 EX	The Hague	+31 70 351 1560	+31 70 351 1548
North Sea Foundation	**Donkers**		Edo	Drieharingstraat 25	3511 BH	Utrecht	+31 30 2340016	+31 30 2302830
Promac BV	**Korteling**		Valentijn	P.O.Box 22	5300 AA	Zaltbommel	+31 418 683333	+31 418 683355
Rotterdam Municipal Port Management	**de Keyzer**	Capt.	Cornelius	P. O. Box 6622	3002 AP	Rotterdam	+31 10 252 1575	+31 10 476 7809
Solits bv	**Boele**		Hen	P.O. Box 126	8260 AC	Kampen	+31 38 3766230	+31 38 3328780
Triqua	**Boom**		Sjoerd	PO Box 132	6700 AC	Wageningen	+31 317 466642	+31 317 466655
Triqua	**van Dijk**		Lex	PO Box 132	6700 AC	Wageningen	+31 317 466642	+31 317 466655
Wagenborg Shipping b.v.	**Dekker**		Peter	Marktstraat 10	9934 CK	Delfzijl	+31 596 636229	+31 596 630985
X - Flow	**Roesink**		Erik	PO Box 141	7670 AC	Vriezenveen	+31 546 581 800	+31 546 581 818
X - Flow	**Van 'T Oever**		Ronald	Bedrijvenpark Twente	7602 KK	Almelo	+31 546 581 857	+31 546 581 818

Nation: **NO**

Company	Name	Titel	First Name	Address			Telephone	Telefax
Aker Yards Prosjektutvikling AS	**Rødset**		Arnstein	Ålesund Kunnskapspark, Serviceboks 9	6025	Ålesund	+47 70 32 92 13	
Det Norske Veritas	**Sletnes**		Hege		1322	Høvik	+47 67579482	
Norsk Inova AS	**Akkerhaugen**		Johannes	Postbox 44	3671	Notodden	+47 3501 7100	+47 3501 2004
Norsk Inova AS	**Otschik**	Dr. Ing. habil	Joachim	Postbox 44	3671	Notodden	+47 3501 7265	+47 3502 9701
Norwegian Union of Marine Engineers	**Andersen**		Helge	P.O.Box 7153 Majorstua	0307	Oslo	+47 23366180	+47 22568610

Company	Name	Titel	First Name	Address			Telephone	Telefax
				Nation: **SE**				
Alfa Laval Marine & Power AB	**Eriksson**		Annsofi	Hans Stahles Vag	14780	Tumba	+46 8 530 657 03	+46 8530 34 555
Alfa Laval Marine & Power AB	**Lindroos**		Harold	Hans Stahles Vag	14780	Tumba	+46 8 530 655 60	+46 8530 34 555
Swedish Maritime Administration	**Gråberg**		Johan	Slottsgatan 82	601 78	Norrköping	+46 11 19 14 07	+46 11 23 99 34
				Nation: **UK**				
BMT Defence Services Limited	**Thomas**		Neil	Maritime House, 210, Lower Bristol Road		Bath BA 23 3DQ	+44 1225 473 791	+44 1225 448 714
Carnival Corporation Shipbuilding	**Storari**		Renato	Alton House, 177 High Holborn		London, WC1V 7AA	+358 9 1942 766	+358 9 664 320
City University	**Seal**		David	Northampton Square		London EcIV 0HB	+44 20 7477 8339	+44 20 7477 8355
Hamworthy KSE Ltd.	**Ballard**		Ian	Fleets Corner		Poole, Dorset BH17 0JT	+44 1202 662600	+44 1202 668793
Hamworthy KSE Ltd.	**Bentley**		Allan	Fleets Corner		Poole, Dorset BH17 0JT	+44 1202 662600	+44 1202 668793
Hamworthy KSE Ltd.	**Smith**		Allan	Fleets Corner		Poole, Dorset BH17 0JT	+44 1202 662680	+44 1202 662818
Hi Tech Marine	**Chapman-Fortune**		John	Lake View Road, Dormans Park		East Grinstead, RH19 2LR	+44 1342 870229	+44 1342 870307
I M O	**Raaymakers**		Steve	4 Albert Embankment		London SE1 7SR	+44 20 7587 3251	+44 20 7587 3261
Mainstar Company LTD	**Toal**		John	PO Box 20		Heswall Cheshire CH61 7YN	+44 151 648 8335	+44 151 648 9430
P&O Princess Cruises	**Duncan**		Caroline	Richmond House ,Terminus Terrace		Southampton SO14 3PN	+44 23 80 534 383	+44 23 80 534 305
QinetiQ Ltd	**Smith**	Dr.	Geoff	Haslar Road Gosport		Hampshire PO12 2AG	+44 23 9233 5129	+44 23 9233 5102
QinetiQ Ltd	**Wood**		Sally	Haslar Road Gosport		Hampshire PO12 2AG	+44 23 9233 5320	+44 23 9233 5102
Strachan & Henshaw Ltd.	**Clayden**		John	PO Box 103		Bristol BS99 7TJ	+44 117 966 4677	+44 117 963 4259
Strachan & Henshaw Ltd.	**Roynan**		Kelvin	PO Box 103		Bristol BS99 7TJ	+44 117 966 4677	+44 117 963 4259

Company	Name	Titel	First Name	Address		Telephone	Telefax
					Nation: **US**		
ATRP Corporation	**Champ**	Dr.	Michael A.	7000 Vagabond Drive	Falls Church, Virginia 22042	+1 703 237 0505	+1 703 241 1278
Delta Marine International Inc	**Hughes**		Ken	1700 NW 65 Ave. Suite 8	Fort Lauderdale, FL 33335-2070	+1 954 791 0909	+1 954 321 8145
Disney Cruise Line	**De Vries**		Frank	PO Box 10210	Lake Buena Vista, FL 32830 0210	+1 407 566 3586	+1 407 566 7599
M. I. T.	**Modell**	Prof.	Michael	23 Fresh Pond Place	Cambridge, MA 02138	+1 617 547 3147	+1 617 864 6628
MPI International	**Maloney**		Gerry F.	1261J No. Lakeview Ave Unit 527	ANAHEIM CA. 92807	+1 909 337 4502	+1 909 337 0736
OptiMarin AS	**Nilsen**		Birgir	190 Henry Street, Bldg 18	Stamford, CT 06902	+1 203 973 0678	+1 413 683 3240
Transtech & Associates LLC	**Szewczyk**		Simon	1151 NW 80 Ave. No 10A	Margate,FL 33063	+1 954 971 0735	+1 954 971 4999
United-Tech Inc	**Spencer**		Bryan	5460 South Garnett	Tulsa, OK 74146	+1 9186 5205	+1 9186 5225

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Exhibition

BETECH ENGINEERING your knowledge partner for

Port Reception (**MARPOL)** Facilities

Conference on

Ballast Water,Waste Water and
Sewage Treatment on Ships and in Ports

12 - 14 September 2001
Bremerhaven -Germany

Willy Vanderpoorten
Guido Everaerts

Introduction

This paper gives some information about the MARPOBEL port reception facility in Antwerp after 18 months of operation.

Main data for the Marpobel plant are :

• Total capacity	:	120,000	tons/year
• Oil storage	:	5,500	m^3
• Waste water storage	:	20,000	m^3
• Berth length	:	1,500	m

Since the start-up, following discharge quality of the treated water was achieved :

• COD	<	100	mg/l
• BOD	<	2	mg/l
• Nitrogen	<	15	mg/l
• Suspended solids	<	5	mg/l
• Heavy metals	<	2	mg/l

The oil recovery facilities of the plant produce marine combustibles according to the ISO-specifications :

• Ash-content	<	0,1	%
• Sediments	<	0,1	%
• Water content	<	0,3	%
• Sludge DS	>	35	%

Feasibility

Until now, neither the Marpol convention, nor the IMO or any other authority has the power to oblige vessels to use the existing port reception facilities for treatment of their black, grey, ballast or bilge waters. Therefore the feasibility of a port reception plant for the treatment of marine sewage only is very uncertain. The concept of the Marpobel plant in Antwerp allows to avoid this problem. The applied technology permits to treat not only sewage from ships but also inland waste streams as well as waste water from the truck and railway car cleaning belonging to the Marpobel installations. Thanks to this concept the Marpobel plant could use its full hydraulic capacity from the beginning.

Technology

Since fiability was one of the main concerns of the Marpobel management, only proven technology was applied in the plant such as:

- pretreatment of the raw wastewater with API separators and a rotating sieve
- physical-chemical pretreatment with a dissolved air flotation unit
- biological treatment with an activated sludge system
- polishing of the effluent with a second dissolved air flotation unit
- sludge dewatering with a filterpress
- oil recovery with a 3 phase oil decanter and a centrifuge.

Biological treatment is very sensitive to changes in the feeding of the raw waste water. A port reception facility as MARPOBEL accepts waste streams with important differences in quality and quantity. Therefore BETECH ENGINEERING designed an activated sludge system with a high degree of flexibility.
The biological treatment consists of a sequencing batch reactor (SBR) which allows the operator to change parameters such as filling, aeration, settling and discharge time. A jet aeration system with **pure oxygen** ensures a very high oxygen transfer efficiency that is almost independent from the capacity of equipment installed in more classic systems such as blowers and all types of aerators. The combination of an SBR system and pure oxygen allows the Marpobel plant to adapt the biological treatment rapidly to changing situations. During the first year of operation, the use of pure oxygen showed even more advantages such as no foaming problems and less odour problems in the aeration tanks.

Future

For the near future we expect that a more severe legislation will rule discharge of waste in the maritime environment , especially within the common market. Therefore , an extension of the treatment capacity and special attention for the treatment of ballast water may be neccessary for the MARPOBEL plant in Antwerp. Adding membrane technology and desinfection equipment can already mean a big step forward without changing the volumes of the reaction and holding tanks.

Conclusion

BETECH ENGINEERING is located in the middle of one of Europe's most important industrial areas and close to the vast chemical industrial network of the port of Antwerp. BETECH ENGINEERING has therefore acquired its experience at first in environmental protection for the chemical industry. This know how combined with the more recent experience of 18 months' operation of the MARPOBEL plant makes BETECH ENGINEERING your knowledge partner for building port reception facilities all over the world. BETECH ENGINEERING can operate as :

- consulting engineers
- engineering company
- turnkey contractor.

BETECH ENGINEERING division of SEGHERSbetter Technology Group N.V.

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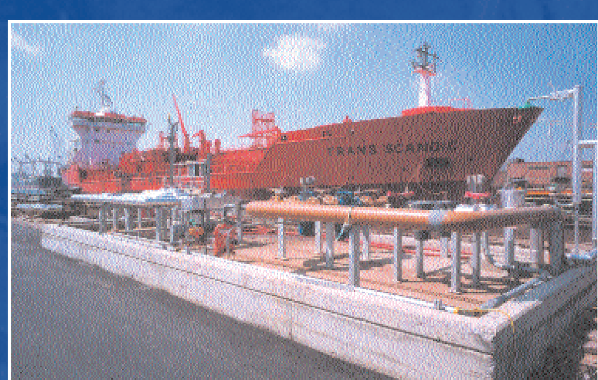
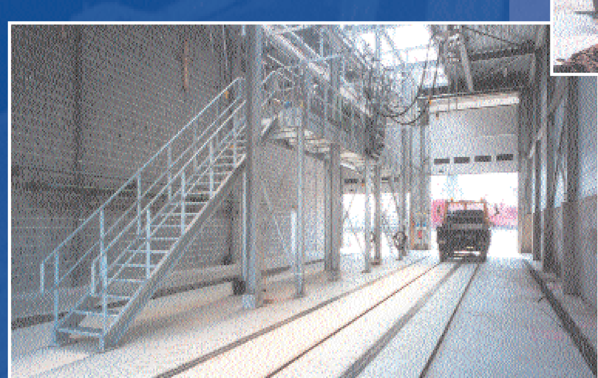
BETECH ENGINEERING your knowledge partner for

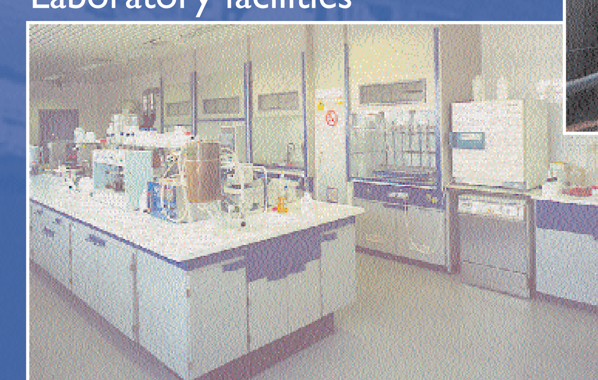
Port Reception (MARPOL) Facilities


Loading and unloading berth

Unloading pit



Tankcleaning

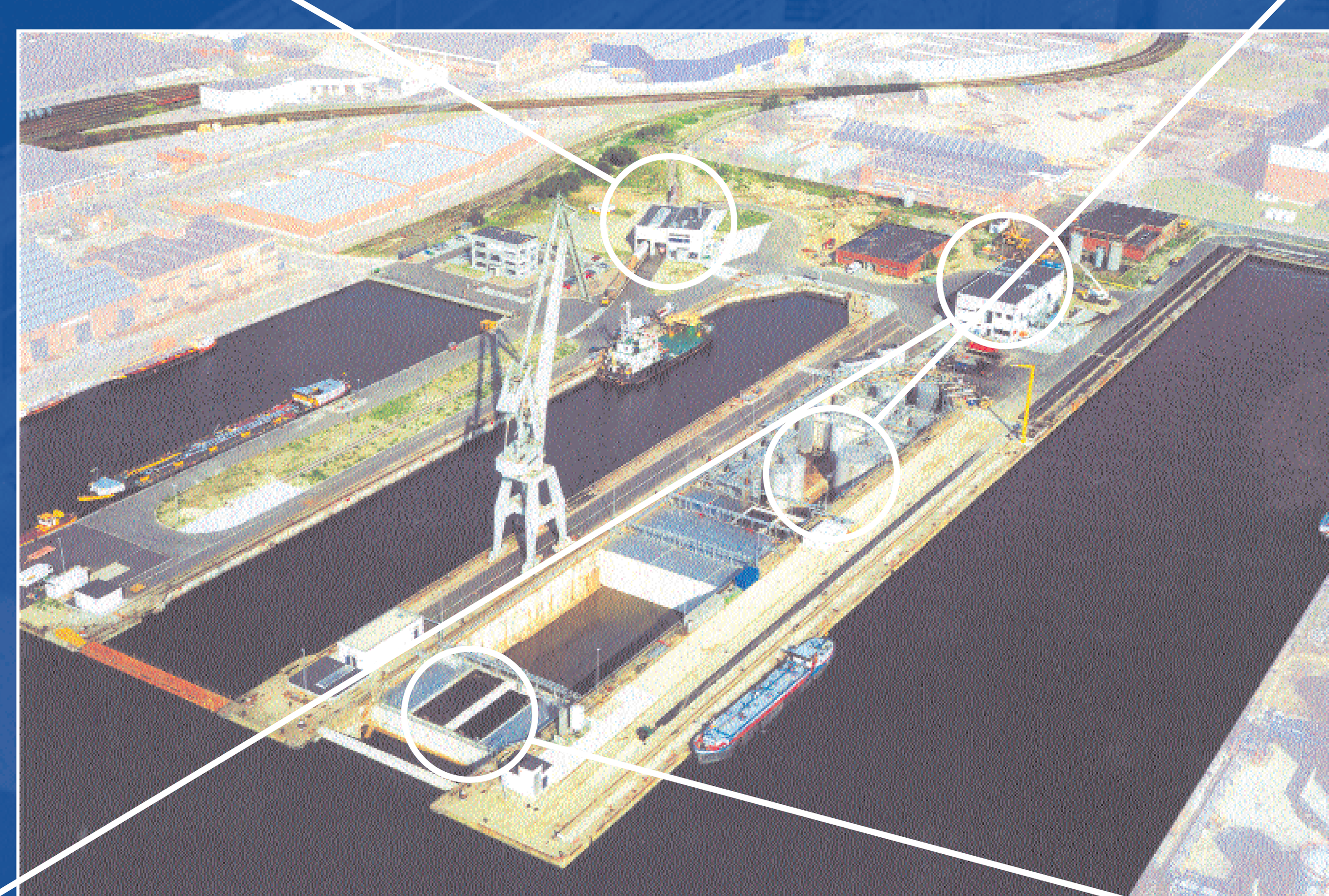
- **Reception of nautical and inland waste streams**
- **Cleaning of ships, trucs and railwaycars**

Laboratory facilities



Waste oil storage tanks

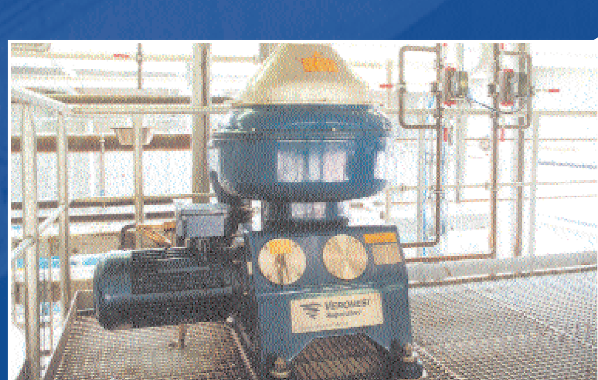

Wastewater basins

- **Waste & oil storage with extensive laboratory facilities**



Marpobel Antwerp BELGIUM:

• Total capacity:	120.000 tons/year
• Oil storage:	5,500 m^3
• Wastewater storage:	20,000 m^3
• Berth Lenght:	1500 m
• In operation since May	2000

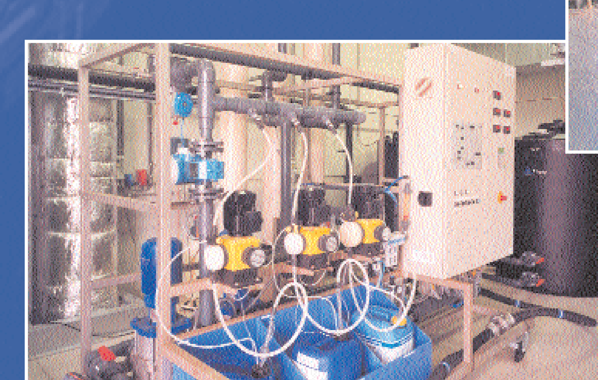

Final oil/water separation

API-separator

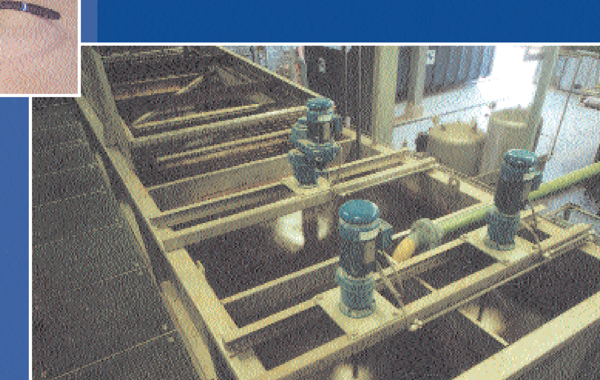


3-phase oil decanter

- **Oil treatment and recovery to meet ISO-standards**




Biological treatment


Physical-chemical treatment

- **Physical-chemical and biological treatment of wastestreams**
- **Membrane filtration and water reuse**
- **Sludge dewatering**

ISO-specifications for marine combustibles

• Ash-content	<	0,1%
• Sediments	<	0,1%
• Water-content	<	0,3%
• Sludge DS	>	35%

Wastewater treatment

	IN		OUT
• COD	up to 50.000 mg/l	<	100 mg/l
• BOD	up to 20.000 mg/l	<	2 mg/l
• Nitrogen	up to 3.000 mg/l	<	15 mg/l
• Suspended solids	up to 10.000 mg/l	<	5 mg/l
• Heavy metals	up to 1.000 mg/l	<	2 mg/l

Mind4D - 5319

BETECH ENGINEERING

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Exhibition

DEERBERG SYSTEMS, GE

See Presentation Session 2

Exhibition

Zenon Environmental Inc., CA

See Presentation Session 2

Technical Product Note

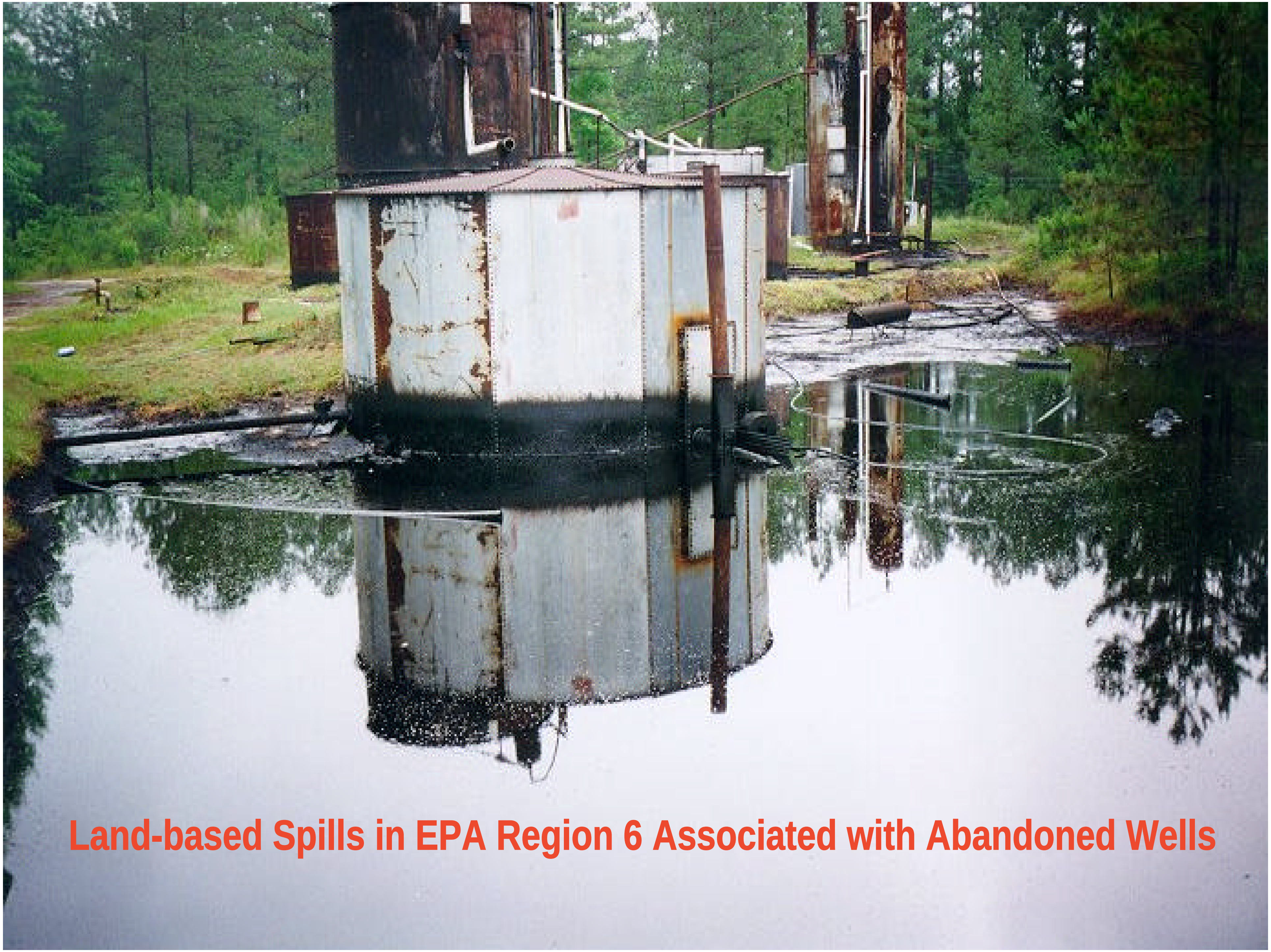
BioSok® Bilge Maintenance Product

Petrol Rem, Inc.

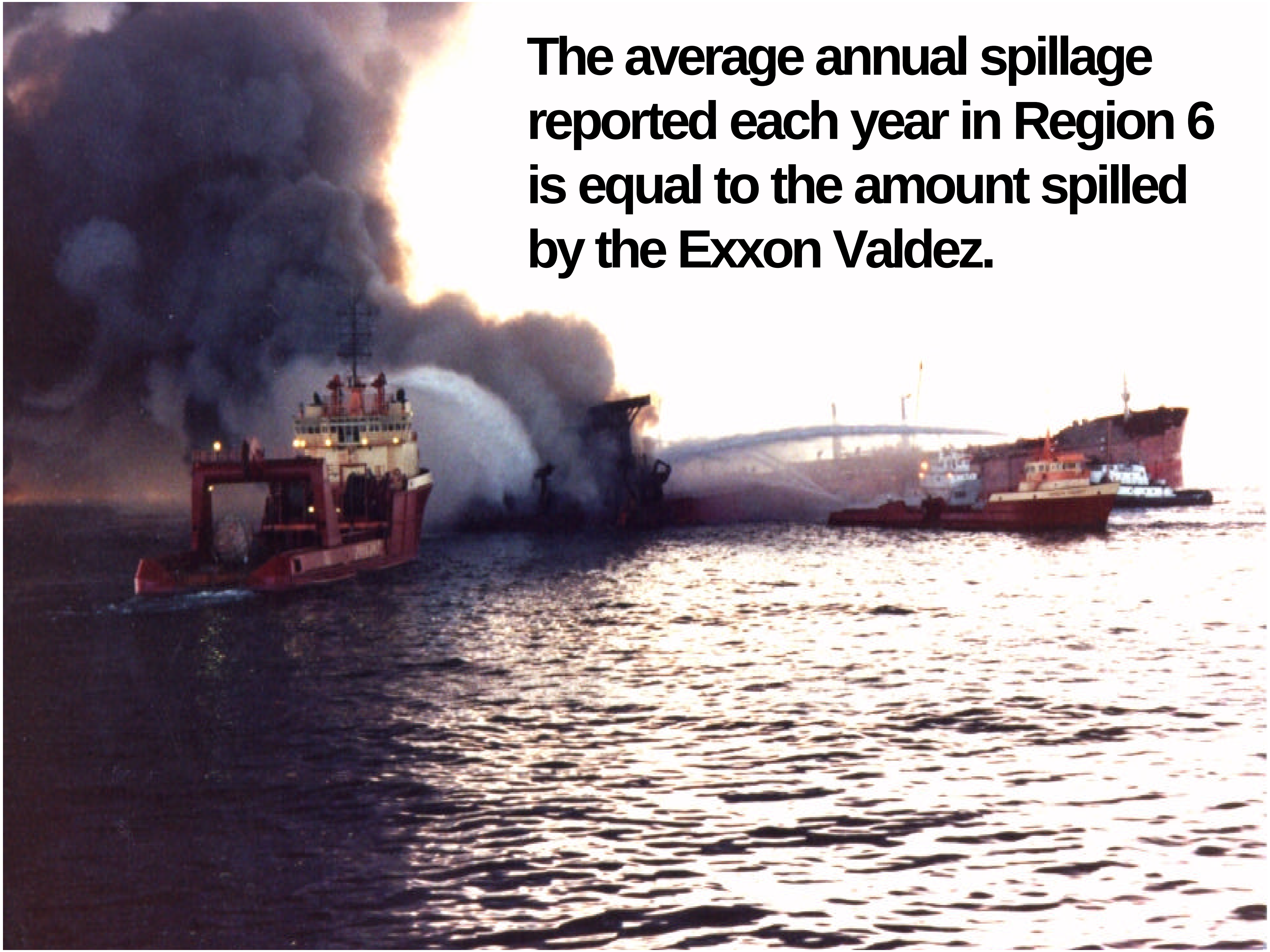
www.petrolrem.com

Michael A. Champ
ATRP Corporation

BioSok® - Bilge Socks



Land-based Spills in EPA Region 6 Associated with Abandoned Wells


The average annual spillage
reported each year in Region 6
is equal to the amount spilled
by the Exxon Valdez.

BioSok® Applications

- In Boat/Vessel Bilges
  - Minimizes Need for Oily Water Discharges and Port/Marina Treatment Facilities.
- Serve as an Absorbent/Bacterial Surface Area Growth Stimulator
  - Larger Spills can use BioBoom® as Spill Response Tool
- PRP® Powder Application
  - To Surface of an Oil Spill on Water
  - Recommended for Ecologically Sensitive Areas

What is BioSok® ?

- Specially Processed Beeswax, called PRP®, encased in a Fabric Bag.
- Not Considered a Nutrient or Bacterial Additive.

BioSok® Work's by:

- PRP® in BioSok® Binds with Petroleum in Bilge
- Providing Surface Area
- Retaining Moisture and Oxygen
- Stimulating Growth of Petroleum Degrading Bacteria
- CO_2 and H_2O are the only Byproducts.

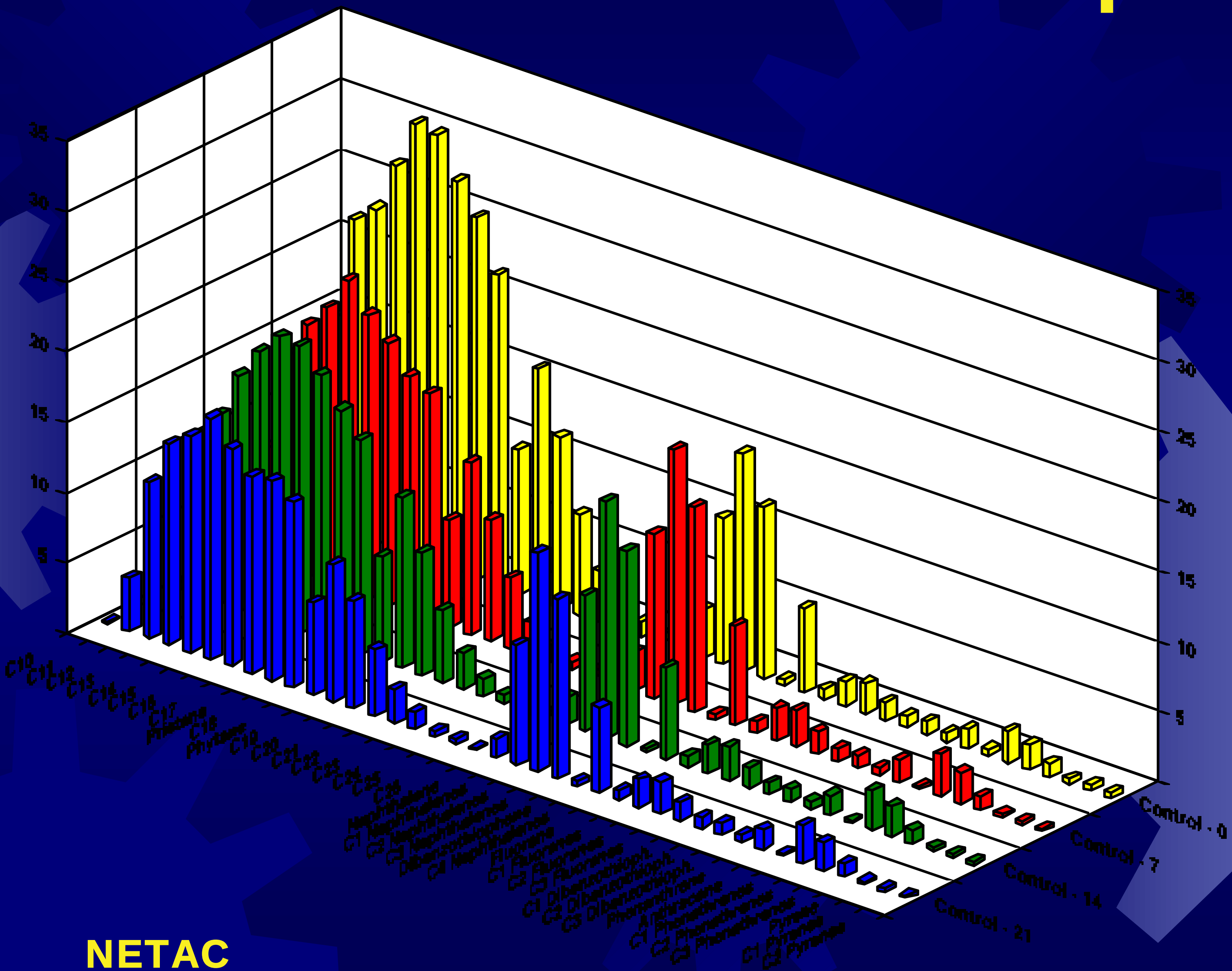
AND:

- Oil Completely Removed from Environment, Not Discharged.
- Empty BioSok® goes to Oily Waste Disposal.

NETAC Mesocosm Study

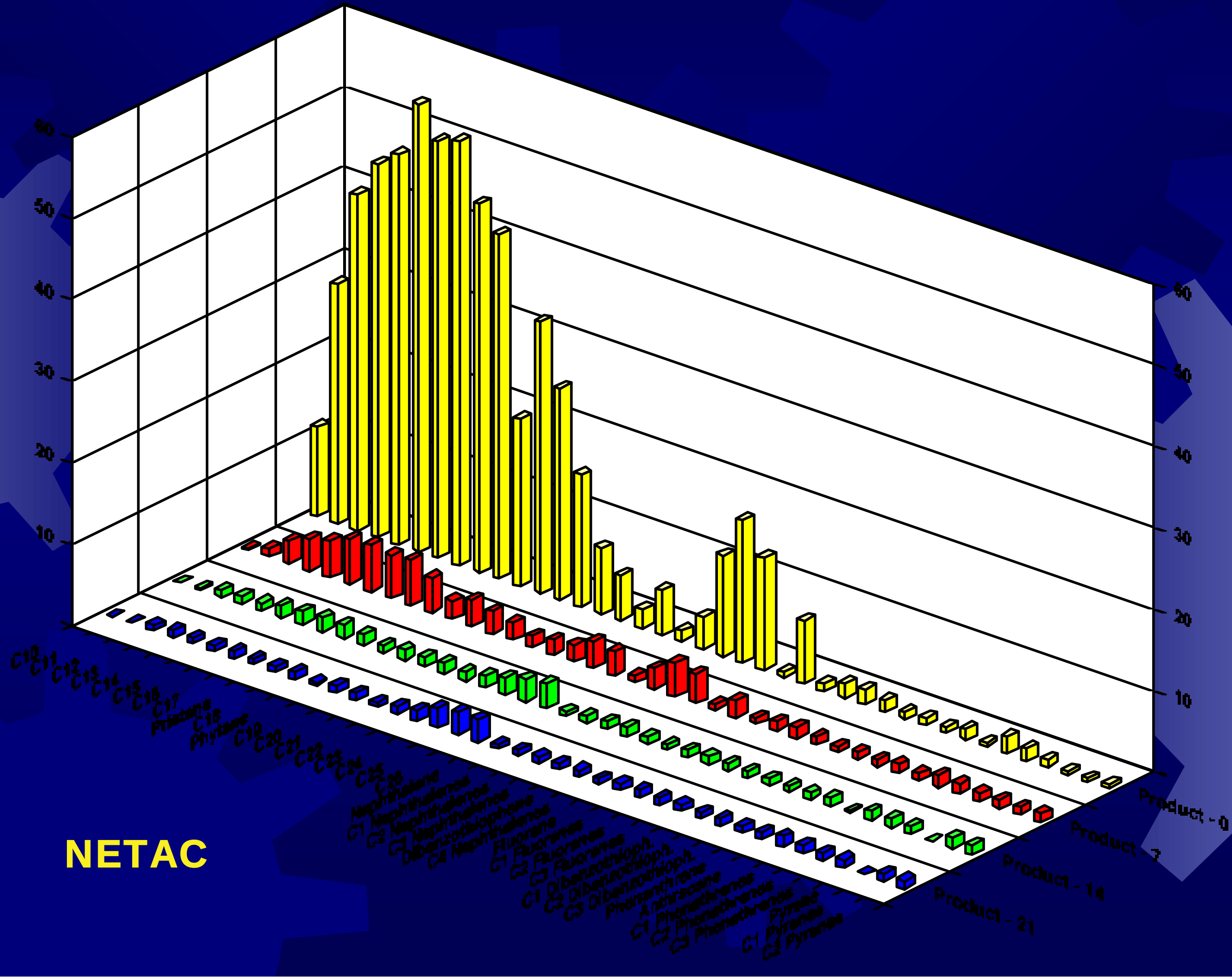
- Large Scale Test of PRP®
- Study Using Natural Water and Diesel Fuel Oil
- Samples 0, 7, 14, 21 Days
- Proven Analytical Methods

Control Spill



NETAC

PRP® Treated



NETAC

Korean Coast Guard Studies

- Performing an Initial Screening Evaluation Before Product Approval
- 15 Day Tests for BioSok® in Simulated Bilge Environment

Day 1

Day 7

Day 15

Korean Study Results:

- BioSok® Increase Natural Degradation Rates of Oil
- Reduces Oily Waste Generation
- Reduces Ship/Vessel Oily Discharges
- Reduces Environmental Impact; and
- Cost Effective

Outline

Introduction

Session 1

Session 2

Supplement

Exhibition