Technical Meeting — 5 September 2018

Daniel Bellagamba, Account Manager Australia East Coast and New Zealand with Wärtsilä Australia, gave a presentation on *Environmental Solutions for Ships* to a joint meeting with the IMarEST attended by 24 on 5 September in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction
Daniel began his presentation with a brief introduction to Wärtsilä Corporation, which currently employs nearly 19 000 professionals at 110 locations in 70 countries around the world. The company's annual turnover is of the order of €5 billion, providing marine solutions, energy solutions and services. Marine solutions (34% of total business) comprises the five segments merchant, offshore, cruise and ferry, navy and special vessels (such as fishing vessels, dredgers, etc.), and provides a comprehensive solutions portfolio. Daniel focussed his presentation on three areas: propulsion efficiency, exhaust gas cleaning systems, and ballast water management.

Propulsion Energy Efficiency
The aim here is to lower the environmental footprint through propulsion efficiency solutions. Key drivers for energy efficiency include the need to cut costs and improve operational efficiency, maritime regulation, and technological advancements.
The target of energy efficiency is to minimise the energy consumed during the whole lifecycle of a vessel. Fuel is the major contributor to the operating cost of the ship. Benefits include:

- Direct cost savings: Savings increase and investment payback time shortens as fuel costs increase.
- Increased competitiveness: Better profitability, offering a possibility to invest in further differentiation and increased revenues.
- Positive effect on brand image: Minimising the environmental footprint with compliance to current and upcoming regulations.

Propulsion efficiency plays an important role in the reduction of fuel consumption and the operational costs of vessels. Wärtsilä has decades of in-house experience of hydrodynamics, extensive knowledge and experience of the entire ship system which helps to develop efficient propulsion systems, can optimise solutions to specific customer requirements, utilises the latest numerical methods for calculations such as computational fluid dynamics (CFD) and model testing, and so can help improve a vessel's energy efficiency.
Here Daniel showed a video on propulsion energy efficiency and some of the improvements which can be made by way of propeller design, wake-improvement devices, propeller boss cap fins, Costa propulsion bulbs, nozzles and two-speed gearboxes [*This video is available at https://www.youtube.com/watch?v=zlxugrT0Zx4&t=14s* — Ed.]

Propeller Optimisation
For a typical propeller, the engine power is distributed as follows:

Rotational losses	5%
Frictional losses	15%
Axial losses	20%
Efficiency	60%
Total	100%

If a vessel changes its operating profile, then there is often a change in operating speed, new powering requirements, different optimal propeller characteristics, and the existing propeller design may not be suitable for the actual vessel operation. For an optimal solution, the requirements must be determined: Is it fuel savings? An increase in bollard pull? Solution of noise and vibration issues? Solution of cavitation erosion analysis? Wärtsilä can investigate the optimal propulsion system by way of a fixed-pitch or controllable-pitch propeller, and any of the devices shown in the video above.
Here Daniel gave an example of a fixed-pitch propeller optimisation:

Item	**Original**	**New Design**
Propeller diameter (m)	8.900	9.000
No. of blades	6	5
Blade area ratio	0.95	0.70
Mass (t)	101	65
Efficiency gain		3.6%

The larger diameter increased the propeller efficiency, and the reduction in number of blades and blade area ratio reduced the frictional losses.

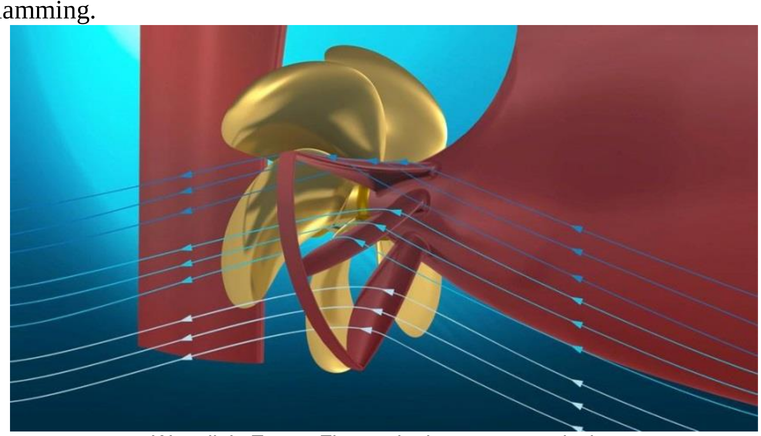
And an example of a controllable-pitch propeller optimisation:

Item	**Original**	**New Design**
Propeller diameter (m)	7.000	7.000
No. of blades	4	4
Blade area ratio	0.68	0.55
Blade mass (t)	5.5	4.5
Efficiency gain		4.5%

The reduction in blade area ratio reduced the frictional losses.

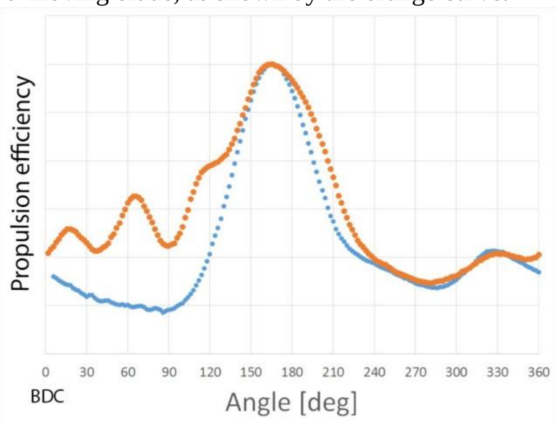
Wake Improvement Devices

Wake improvement devices aim to improve the inflow to the propeller by guiding one side of the stern flow in the opposite direction to the propeller rotation, generating pre-swirl. Devices such as Wärtsilä's EnergoFlow consist of multiple curved fins and a ring attached to the ship's hull. to prevent the power losses which typically occur in a propeller's slipstream. The curved fins enhance the propeller's efficiency while keeping resistance at acceptable levels. The ring reduces the tip vortex and levels out the peak stresses which occur in severe loading conditions such as slamming.



Wärtsilä's EnergoFlow wake improvement device
(Image courtesy Wärtsilä)

The propeller blade efficiency varies during one revolution depending on the local inflow due to the wake field. The blue curve in the accompanying diagram shows the variation in blade efficiency over one rotation for a four-bladed propeller. After applying Wärtsilä's EnergoFlow, efficiency increases mostly between 0˚ and 120˚, which is the zone of the upward-moving blade, as shown by the orange curve.



Efficiency gain due to Wärtsilä's EnergoFlow wake improvement device
(Image courtesy Wärtsilä)

Propeller Boss Cap Fins

Propeller boss cap fins aim to reduce rotational losses. The cap fins reduce the boss vortex strength significantly and recover kinetic energy from induced rotation. They are applicable to all vessel types, and provide an average energy saving of 2%. The EnergoProFin is Wärtsilä's device.

The vortex coming from the propeller can cause cavitation damage on the rudder. Installing cap fins can reduce rudder damage due to reduced boss vortex, and installation of the cap fins does not affect the manoeuvrability of the vessel.

Installation of the cap fins can be performed by a shipyard during dry-docking, or afloat with the help of divers, typically taking one day.
Wärtsilä has had more than 190 EnergoProFins installed since their introduction, and can provide service engineers for local installation support.

Nozzles
Nozzles, or the application of ducted propellers, are suitable for vessels with high propeller loads, such as tugs, trawlers, seismic vessels, dredgers, and the like. Typical benefits include an increase in bollard pull, and a reduction in noise and/or vibration.

Process
A typical process for a Wärtsilä propulsion optimisation takes place in three stages:

1. Quick Scan

This involves an investigation of the operating profile, propeller diameter, number of blades and optimal RPM, with rudimentary calculations and a rough estimation of savings. This results in a one-page report which is free of charge.

2. Detailed Study

This involves a propeller pre-design and an accurate calculation of savings, and results in a full report.

3. Engineering Project

This involves model testing, all documentation required for manufacturing and installation, production and testing.

Propulsion Examples
Here Daniel gave a number of examples of vessels which Wärtsilä had investigated and for which they had provided propulsion energy efficiency improvements, including a large fishing vessel, a fleet of twelve 9000 TEU container vessels, a twin-screw ferry, a fleet of six 6700 TEU container vessels, a ro-ro container vessel and a coaster.

Exhaust Gas Cleaning Systems
Daniel next turned the focus onto exhaust gas cleaning systems, and began with a world map of the existing and future emission control areas (ECAs). Existing areas include the east and west coasts of the USA and, in Europe, the North and Baltic Seas. Future areas include the coasts of Mexico and the remaining coasts of Europe, the coasts of Japan, and some coasts of China.
The International Maritime Organization (IMO) is standing its ground on the enforcement of the 2020 sulphur cap which means that, as of 1 January 2020, ships will be banned from burning any marine fuel with a sulphur content above 0.5%. IMO's Sub-Committee on Pollution Prevention and Response (PPR) has approved draft amendments to the MARPOL convention on the prevention of pollution from ships (MARPOL Annex VI) to prohibit the carriage of non-compliant fuel oil. The exception would be ships fitted with an approved "equivalent arrangement" to meet the sulphur limit—such as an exhaust gas cleaning system or so-called "scrubber"—which are already permitted under regulation 4.1 of MARPOL Annex VI. More than 70 000 ships will be affected by the regulation.
In a recent report, Clarkson Research stated that more than 25% of the global orderbook is confirmed with a scrubber. However, this only translates to 3% of the entire fleet. Clarkson data suggests that come 1 January 2020 when the sulphur cap kicks in, up to 90% of the global merchant fleet will be relying on more-expensive compliant fuel to power their ships.

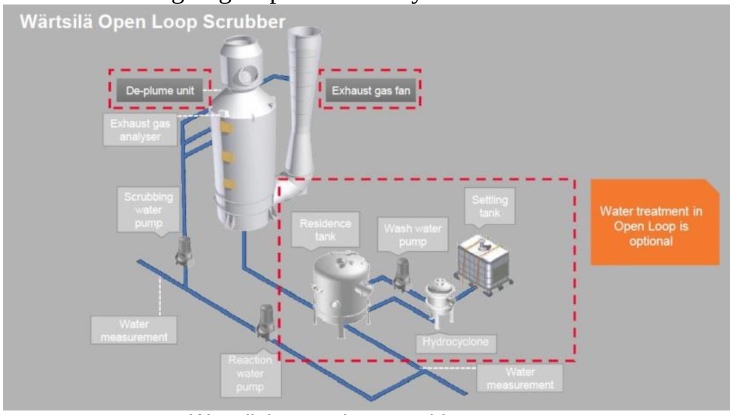
Alternatives for Reducing SOx
For the 2020 deadline, there are essentially four choices available:

- Using very-low-sulphur fuel oil or compliant fuel blends (0.50% sulphur). This requires only a small investment and is flexible, but has a high operating cost based on present fuel prices, and there is a question mark about availability of such fuel.
- Switching from high-sulphur fuel oil to marine gas oil or distillates. This requires only a small investment and is convenient, but has a high operating cost and there is a question mark about future availability.
- Retrofitting vessels to use alternative fuels such as LNG or other sulphur-free fuels. This solution also reduces NOx and particulates, but has a high investment cost, and LNG is not yet widely available.
- Installing exhaust gas cleaning systems (scrubbers), which allow operation on regular high-sulphur fuel oil. This works with high-sulphur fuel oil, has the lowest total life-cycle cost, is used everywhere and is easy to operate, but the payback period depends heavily on the fuel price difference between low-sulphur and high-sulphur fuel oils.

Considerations
The global demand for distillates is likely to increase, so the price of MGO is expected to increase while the price of HFO is expected to stay the same or even decrease.
Scrubbers have been demonstrated to work in the marine environment, and allow for the same bunkering and same engine operation as before. European and North American sulphur ECAs are already in force, and more are expected. Wärtsilä has a large portfolio of marine scrubber solutions which are fit for new buildings and retrofits, and for any engine and boiler brands.

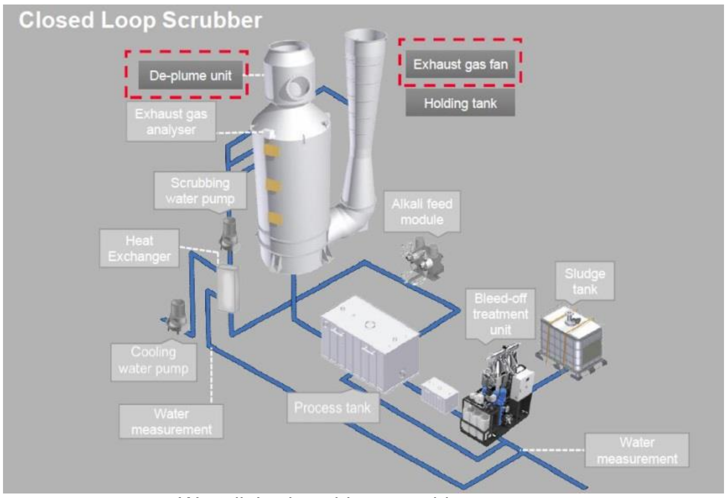
Wärtsilä Scrubber Systems
Wärtsilä has three types of scrubber systems:

Open-loop Scrubber
This system operates in an open loop utilising seawater to remove SOx from the exhaust. Exhaust gas enters the scrubber and is sprayed with seawater in three different stages. The sulphur oxide in the exhaust reacts with water and forms sulphuric acid. Chemicals are not required since the natural alkalinity of seawater neutralises the acid. Wash water from the scrubber is treated and monitored at the inlet and outlet to ensure that it conforms with the IMO discharge criteria. It can then be discharged into the sea with no risk of harm to the environment.
This is the main alternative for ocean-going ships and an easy solution.



Wärtsilä's open-loop scrubber system
(Image courtesy Wärtsilä)

Closed-loop Scrubber
In this system, the exhaust gas enters the scrubber and is sprayed with sea water which has been mixed with caustic soda (NaOH). The sulphur oxides in the exhaust react with this mixture and are neutralised. A small bleed-off is extracted from the closed loop and treated to fulfil IMO requirements. Cleaned effluents can be safely discharged overboard with no harm to the environment. If operation in zero discharge mode is requested, then the effluent can be led to a holding tank for scheduled and periodical discharge.
This would be the choice for seas with extremely low alkalinity and for operators looking for continued closed-loop operation.

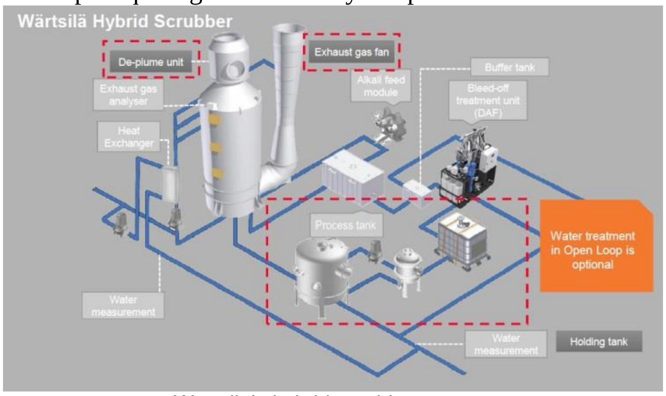


Wärtsilä's closed-loop scrubber system
(Image courtesy Wärtsilä)

Hybrid Scrubber

Hybrid solutions have the flexibility to operate in both open- and closed-loop modes. This provides a flexibility of operation in low-alkaline waters as well as the open ocean. The hybrid approach enables operation in closed loop mode when required, for instance whilst in port and during manoeuvring, using NaOH as a buffer. The system can be operated in zero-discharge mode for a limited period. When at sea the switch can be made to open-loop using only seawater.

This would be the choice for ships requiring full flexibility of operations.



Wärtsilä’s hybrid scrubber system
(Image courtesy Wärtsilä)

Scrubber Examples

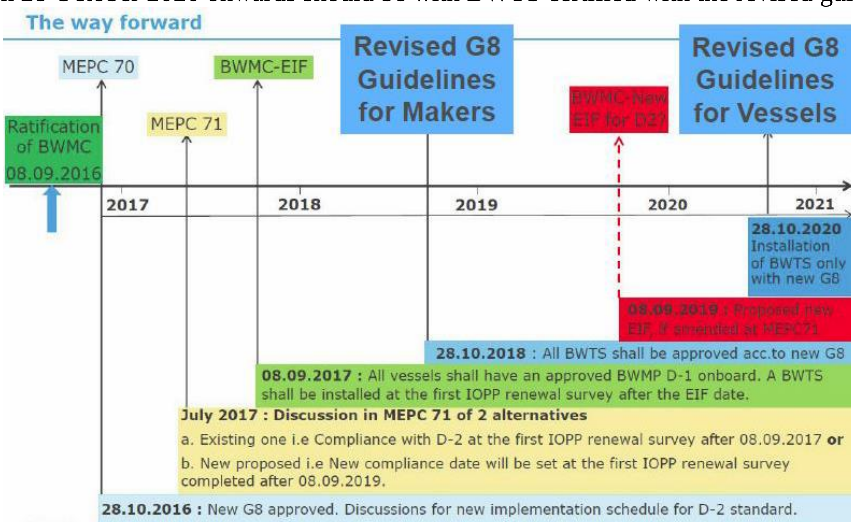
Here Daniel gave a number of examples of vessels which Wärtsilä had investigated and for which they had provided scrubber solutions, including a 70 000 dwt product tanker, *Harmony of the Seas* (the biggest cruise vessel with the biggest scrubbers!), *Clipper Quito* and *Clipper Posh* (the first of a series of very large gas carriers), *Thalata* (car carrier). To date, Wärtsilä has supplied over 310 scrubbers, mainly to container vessels (30%), but including VLCCs, tankers, ro-ro vessels, bulk carriers, cruise vessels, ro-pax vessels and trawlers.

The lead times for a project are typically 8–10 weeks for feasibility and budgeting up to the award of a contract, and then 9–10 months for engineering, procurement, construction, installation, testing and trials.

Ballast Water Management Systems

Daniel next turned the focus onto ballast water management systems, and began with a video of the threat posed by ballast water transport and Wärtsilä’s systems [*This video is available at https://www.youtube.com/watch?v=M2oAol_dxPY* — Ed.], followed by details of the implementation schedule required by IMO’s *Guidelines for Approval of Ballast Water Management Systems (G8)*, adopted on 28 October 2016.

Ballast water treatment systems which will be installed (i.e. delivered on board a vessel) prior to 28 October 2020 should be certified either with the existing G8 (2016) guidelines or the revised version. The latter allows early movers to use their installed systems as long as they maintain and operate them properly. The revised guidelines will be applied on BWTS which start their Type Approval process from 28 October 2018 onwards. Installations from 28 October 2020 onwards should be with BWTS certified with the revised guidelines.



Ballast water treatment system implementation schedule
(Image courtesy DNV GL)

Treatment Systems

There are two main types of ballast water treatment systems: one using electro-chlorination which can treat more than 1500 m^3/h and is suitable for tankers and bulk carriers, and one using ultra-violet light which can treat up to 1000 m^3/h and is suitable for containerships and most other vessels. Both are type approved and USCG compliant.

For an electro-chlorination system, the typical scope of supply includes the main control panel, EC power supply, side-stream pumps, electrolysis cells, dosing/degassing unit, neutralisation unit, static mixer and filter.

For an ultra-violet system, the typical scope of supply includes the main control panel, UV power supply, filter and UV treatment unit.

Retrofitting options can include supply only, engineering, site advisory, and complete installation.

Steps to Compliance

The following are the usual six steps to compliance:

Initial Phase

This phase covers collection of data on the vessel and its operating profile, preliminary price indications based on similar previous projects and estimates, and choice of technology and loose, modular or bespoke systems.

Concept

An onboard technical survey of the vessel is carried out, and an equipment configuration developed based on the survey and proposed BWMS setup. Capital expenditure and operating expenditure estimates are made, and a technical feasibility report prepared.

Basic Engineering

The proposed installation site of the vessel is 3D laser scanned in order to produce full mechanical and engineering drawings and documents for the installation. Dialogue is opened with the classification society for preliminary approvals, sub-contractors are selected and a firm offer and contract for supply made.

Detailed Engineering

This includes detailed mechanical and electrical engineering, production drawings including e.g. steelwork detailed drawings, welding details, and foundation drawings, capacity calculations and diagrams, equipment and valve lists, class approvals for drawings, and procurement.

Installation

Equipment is delivered for prefabrication and installation, with system delivery as loose kit or pre-assembled modules, including all components mounted on skids and internal cabling connected, followed by installation at the yard during docking, and installation onboard before and after docking.

Commissioning

Testing and commissioning includes crew training in operating the system, flag and class approvals, and handing over and start of lifecycle support

Warranty

The warranty period is typically one year. Life-cycle support includes guaranteed availability of spare parts and services throughout the life of the system, and guaranteed service network and availability.

Wärtsilä's BWMS

Wärtsilä has 11 000 service professionals with leading technology know-how in many countries of the world. They have ballast trained personnel in the UK, Korea, China, Netherlands, Singapore, USA, Italy, Finland, India, Greece, France, Germany, Norway, Japan, Turkey and UAE, and more are coming!

The Wärtsilä Land & Sea Academy also runs courses in Ballast Training [*The Wärtsilä Land & Sea Academy has operations in 12 countries, and runs a huge number of courses (listed in the Training Program Catalogue) intended for personnel of any Wärtsilä equipment owner, see https://www.wartsila.com/wlsa* —Ed.]

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by George Curran.

Daniel Bellagamba (L) accepting the “thank you” bottle of wine and certificate from George Curran
(Photo Phil Helmore)