Clean solutions for ships

examples from the Port of Göteborg

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Photo: Large photos on all ships and small photos on
M/T Tärnholm and M/V Manon, submitted by the ship owners.
Other photos, where nothing else is indicated, by Jan Ahlbom and Ulf Duus.

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Why this paper?

The Port of Göteborg. Photo: Bewe bild AB.

Shipping has an irreplaceable function as conveyer of people and goods all over the world. Shipping is also basically an environmentally sound means of transport. It has comparatively low demands on infrastructure and can transport large quantities of goods at a low consumption of energy.

Transport at sea is increasing and good opportunities exist for further growth. The international character of shipping has, however, led to an exemption from a large portion of the environmental demands put on landbased means of transport and enterprises. Shipping today is encumbered with a number of health and environmental problems. But these can and must be resolved.

The Clean Ship

In the Bergen Declaration of 2002, the Ministers responsible for the protection of the environment of the North Sea defined the Clean Ship as "vessels designed, constructed and operated in an integrated manner to eliminate harmful discharges and emissions throughout their working life".

This is an important long-term vision and goal, but also a long journey has to start with a first step. There are several measures that could be taken on a large number of ships operating today, leading to a significant decrease in health/environmental impact. This even if zero emission will not be reached. Examples of measures for a "clean ship of today" are mentioned below. It may include the use of:

- ***NOx emission abatement techniques***
- ***Low sulphur fuels***
- ***Active bilge water cleaning equipment***
- ***Environmentally adapted lubricants i.e. stern tube oils, external hydraulic fluids and lubricant grease***
- ***Environmentally adapted cleaning agents***
- ***Antifouling coatings with as low impact on the environment as possible***
- ***Environmentally adapted boiler and cooling water treatment***
- ***Shore-side electricity at berth***
- ***Different energy saving measures (lower speed, frequency modifiers etc)***

Good examples

The object with this paper is to demonstrate a number of good, well-functioning environmental solutions made on a selection of ships regularly calling at the Port of Göteborg. All the measures go beyond existing regulations.

The selection is made to reflect different types of vessels. It must be stressed though that these are just some examples – there are a number of ships with good environmental performance calling at the Port of Göteborg.

By showing these examples we hope to stimulate others to adopt some of the ideas and to be even more innovative in finding environmental solutions. An object is also to encourage large transport buyers to start asking for clean solutions in their shipping activities. We want to influence politicians to create effective incentives for a change-over process – but also to work for international regulations for further environmental measures.

Finally we want to forward the sense that we have met in many engine rooms, messrooms and on many ship bridges – namely that the problems are possible to solve!

M/V SCHIEBORG

M/V Schieborg *is a RoRo vessel built in Lübeck, Germany in the year 2000. She is owned by Wagenborg Shipping in Delfzijl, The Netherlands. Together with the two identical sister ships M/V Slingeborg and M/V Spaarneborg, she operates regularly between Göteborg and Zeebrugge on behalf of the large paper producer Stora Enso.*

M/V Schieborg and her sister ships are designed for a special transport system – the Stora Enso Cargo Unit (SECU). The system is based on large boxes loaded inside the paper mills, transported by train to Göteborg and transferred by trucks over to the ship. In Zeebrugge the SECUs are reloaded for continued rail, road or sea transport.

On the demand of Stora Enso the ships have been equipped with a number of devices for good environmental performance. The object is to get an efficient and environmentally adapted global transport system of Stora Enso products. The Belgian company Cobelfret is hiring some space on each ship for trailer and container transports.

Clean fuels

M/V Schieborg has a deadweight of 12,457 tonnes, a lenght of 183.4 metres and a maximum draught of 7.5 metres. There is a total of 2660 load metres on the three cargo decks. The gross tonnage is 21,005. A loading record is 5300 tonnes an hour.

The main engine of M/V Schieborg is a Sulzer 7 RTA 52U two-stroke diesel of 10,920 kW at 135 rpm. The auxiliary engines are two Wärtsilä 6L20 four-stroke engines of 1000 kW each. The main engine runs on low-sulphur heavy fuel oil HFO 380 (< 1% sulphur) and the auxiliary engines on marine gas oil, MGO (< 0.2% sulphur). Usually M/V Schieborg bunkers 800 m^3 HFO every 3rd to 4th week.

Maximum speed is 19.5 knots but normally the ship sails around 15 knots – partly for environmental reasons. A rough median consumption is 30 tonnes HFO/24 h. Auxiliary engines are only used going in and out of harbours and in rough weather.

Selective Catalytic Reduction

A ship using standard heavy fuel oil in its engines may well emit 17-20 g nitrogen oxides /kWh at 135 rpm. Nitrogen oxides (NO_X) is formed during the combustion process by N_2 and O_2 in the air. The nitrogen content in the fuel is of minor importance. To reduce NO_X emission you can either prevent NO_X forming or you can perform post combustion conversion back to N_2 and H_2O.

On M/V Schieborg both the main engine and the auxiliary engines are equipped with Munters Selective Catalytic Reduction (SCR) Converter System in order to reduce primarily NO_X emissions but also hydrocarbons and carbon monoxide. By injecting a urea solution into the engine exhaust a major reduction of NO_X to nitrogen and water is accomplished by the converter. The emissions of NO_X from M/V Schieborg is newly measured to < 0.2 g NO_X/kWh, equal to a 99% NO_X reduction.

The M/V Schieborg urea consumption is about 10% of the HFO. The price of urea is slightly less than the price of HFO per weight. The ship has two 50 m^3 tanks for urea solution which is filled regularly, usually in connection with the fuel bunkering. Urea is a principally innocuous substance in this context. Bunkering of M/V Schieborg always take place at berth.

SCR - Selective Catalytic Reduction

By SCR a 40% solution of urea $(NH_2)_2CO$ and water is injected and evaporated in the hot exhaust gas directly after the engine. Exhaust temperature should be 270-500° C. The mixture is passed through the catalytic converter consisting of 3 steps with ceramic material of vanadium pentoxide where exhaust NO_X is converted to N_2 and H_2O.

A fourth oxidation step with platinum may be fitted for additional reduction of hydrocarbon and carbon monoxide emissions. This could be an adequate measure for auxiliary engines, generally run in ports.

The SCR method reduces the NO_X emissions by 85-99% depending for example on the urea injection rate. An emission of 17 g NO_X/kWh is equivalent by weight to the SO_2 emission/kWh from 4% sulphur content in the fuel for a slow speed engine.

SCR need some space to be fitted but it is usually manageable. Considerate volumes of urea has to be stored on board and refilled regularly. A reduction cost around 0.3-0.6 eur/kg NO_X have been calculated. (Swedish NGO Secretariat on Acid Rain)(Acid News)(Munters)(Lloyds)

Shore-side electricity

Already in the construction phase for M/V Schieborg and her sister ships it was planned for shore-side electricity installation. In both Göteborg and Zeebrugge 11 kV power is available at quayside. On shore the power is transformed to 6 kV before taken on board. On the ship it is transformed to 400 V. The frequency is 50 Hz.

It takes about 10 minutes after the ship is safely at berth before the shore-side electricity is connected and the auxiliary engines may be closed down. The only exception is during bunkering operations when the auxiliary engines are run for safety reasons.

Positive effects are no air emissions from the ship at berth but also low noise. This is beneficial both for those working on board and for people on shore. M/V Schieborg consumes about 3000 kW/eight hour at berth.

Shore-side electricity

The most effective way to cut emissions in port via shore-side electricity is to focus on ships with the most frequent visits. These ships are also likely to be more suitable for shore-side electricity connection as compared to other vessels.

The following parameters are of importance for installation of shore-side electricity:

- ***Shore-side frequency (50 Hz in Europe)***
- ***Onboard frequency (60 Hz or 50 Hz)***
- ***Shore-side supply of high voltage electricity***
- ***Required power level***
- ***Available space for onboard transformer, and weight restrictions of the vessel.***
- ***Onboard cable installation practicalities.***
- ***Cost for shore supplied electricity versus the electricity generated on board.***

The two parameters that have the greatest impact on the installation cost for shore-side electricity are changing the onboard frequency and supplying the quay with high-voltage electricity.

Calculations have shown that "external" emission costs (i.e. the total costs for society) for onboard power generation are much higher than the total direct costs for electricity from a shore-side power connection.

A common international practice or standard for shore-side electricity connections would certainly speed up the implementation of this measure. (MariTerm)

Stern tube lubrication

An environmentally sensitive spot on a ship is the stern tube. This is where the propeller shaft passes through the hull. Seals are installed to hinder leakage of water into the ship. At the same time the propeller shaft has to be lubricated in the stern tube. The lubrication fluid is usually under over-pressure so if the shaft is getting somewhat warped – which often happens over time – fluid is going out of the ship.

M/V Schieborg has installed a closed Thordon lubrication system based on a non-toxic, readily biodegradable lubricant (ThorLube) dissolved 1:9 in fresh water. This is stored in a 4 m^3 tank and slowly pumped around in the system. Salt water contamination is checked at regular intervals. The bearings are also Thordon consisting of a special elastomer and the system is closed with a so called aft mechanical face seal. Thordon can also offer an open completely water-lubricated system with only a forward stern tube seal.

Stern tube lubrication

A propeller shaft generally becomes a little warped over the time. Wires and nets can also be dragged into the propeller and damage seals in the stern tube. The elasticity of the seals can also be altered by for example additives in the lubricants. Considerable amounts of lubricant oil can gradually leak out into the sea.

A rule of thumb sometimes used is that up to 1% of the thickness in millimeters of the seal is an acceptable leakage level counted as litres per 24 hours. A 600 mm seal may consequently leak about 6 litres of oil/24 h without measures being taken. That could add up to 2 m^3 of oil/ per year and propeller. Loss volumes of that magnitude have also been reported from for example Swedish passenger ferries. More serious incidents may lead to very large leakages. The total emissions of stern tube oils from the global merchant fleet have by some actors been estimated at around 60,000 m^3/year.

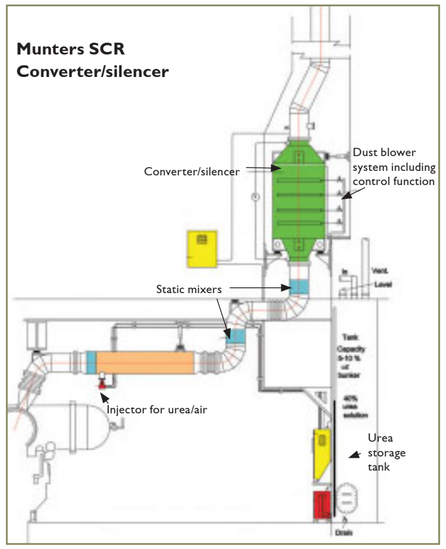
Engine oil or gear oil is often used for the stern tube lubrication. These oils contain a large number of additives where many are redundant in a stern tube. The additives are often toxic to aquatic organisms, persistent in the environment and have a potential to accumulate. The base oil itself is usually of petroleum origin and does not biodegrade quickly.

Sea-water cooling

Usually the cooling water for the engine consists of a high-temperature and a low-temperature system. The low-temperature system in its turn, is cooled by a sea-water system. It is important though that the sea-water system does not get choked with macrofouling like algae and mussels. This may jeopardize the whole cooling system. Traditionally strong organic biocides like dithiocarbamates are intermittently dosed in the sea chest and most of it ends up in the sea.

On M/V Schieborg a system with copper and aluminum electrodes are installed in the two sea chests. A weak current induces copper ions from the anode which inhibits macrofouling in the system. Copper ions are deactivated quickly in the sea-water and does not have the same hazardous environmental profile as for example dithiocarbamates.

Urea injection



Clean exhaust

Stora Enso Cargo Unit (SECU)

SCR on the main engine

135 m propeller shaft

Cable brought down from the ship

Connected!

Copper-aluminum electrodes

M/T TÄRNHOLM

M/T Tärnholm *is a tanker for oil products and chemicals, built in Shanghai in 2005. It is owned and run by Tärntank Rederi AB, situated on the island of Donsö just outside the Port of Göteborg. It has a deadweight of 14,796 tonnes, a length over all of 141 metres and a moulded depth of 11.5 metres. M/T Tärnholm has a cargo tank capacity of 15,807 m³ and is mainly used for transport of gasoline and diesel fuels in the Baltic Sea and the North Sea. The ship has a double-skinned hull. It is regularly calling at the Port of Göteborg. M/T Tärnholm may carry 576 m³ heavy fuel oil (HFO) and 96 m³ marine gas oil (MGO). The ship consumes 22 tonnes HFO/ 24 h, at normal speed and load.*

Clean fuels at berth

The main engine is a Wärtsilä Type 6L46C, four-stroke medium speed giving 6300 kW at 500 rpm. The main engine is run on standard heavy fuel oil, HFO 380 cSt. Auxiliary engines are three Caterpillar 3508B connected to CAT generators of 750 W. They are all run on marine gas oil (MGO) with a sulphur content < 0.2% and a content of polycyclic aromatics (PCA) < 1%. At berth the main engine on M/T Tärnholm is shut down and MGO is the only fuel used.

As the ship is built after the year 2000 it has to comply with the nitrogen oxides (NOx) emission regulation of Annex VI of MARPOL 73/78. The emissions from M/T Tärnholm are < 6 g NO_X/kWh, which is far below the limit.

Bunkering control equipment

Transferring fuel oil from a bunker boat to a recieving ship always constitutes a risk. Especially at sea where an over-bunkering may have devastating environmental effects.

M/T Tärnholm is regularly bunkered at berth. She is also equipped with very efficient supervision systems for bunker and cargo tanks from SAAB Rosemount Marine.

The principle for supervising the bunker tanks is based on bubbles of air injected in the tank. The system is called LevelDatic. The injection pressure needed is accurately registered by a sensor indicating the oil level in the tanks. A number of alarm systems is activated if the levels becomes critical. With this system you minimize the risk of getting overloaded tanks and fuel oil emitted into the sea or the harbour.

For cargo tanks a system based on radar technology is used called TankRadar. The system is extremely reliable for level gauging, with high level and overfill alarm.

TankRadar

Auxiliary engine

Emissions in ports

Today many large ships at berth use heavy fuel oil (HFO) for auxiliary engines, producing electricity for the ship. This is mainly for economic reasons as the cost of standard HFO is around 300 USD/tonne and of MGO around 575 USD/tonne (March 2006). Motor developments have made it possible to use fuels of lower quality also for auxiliary engines.

A standard HFO contains on average 2.7% sulphur by weight and sometimes up to 20% carcinogenic polycyclic aromatics (PCAs). Aside of the acidification effect and the degrading effect on materials of the sulphur emissions, there are health effects which makes it extra undesirable to burn standard HFO in densely populated ports and harbours.

Transformation to sulphate particles can induce asthma, bronchitis and heart failure. Small particles in general gives rise to a calculated number of 348,000 premature deaths per year in the whole of EU (CAFE-programme). Sulphur emissions from ships equals about 40% of the total sulphur emissions from landbased sources within EU – a figure constantly increasing. (Entec)

The carcinogenic PCA emissions are proportional to the amount found in fuel. Studies made in the Port of Göteborg shows that one large ship entering the harbour emits the same amount of PCA as 1200 heavy diesel trucks. Ships at berth running auxiliary engines on HFO emit PCA in the same magnitude per kWh, as the emissions from the main engines. (Ahlbom, Duus)

In the marine fuels Directive adopted in 2005, there is a 0.1% sulphur limit on fuel used by inland vessels and by seagoing ships at berth in EU ports, from 1 January 2010. (EU Commission)

Handling of heavy fuel oil

M/T Tärnholms main engine is of the four-stroke type and the engine room is generally far more clean than engine rooms with two-stroke engines. One reason for this is less ”engineering” with oily machine parts. Hence is the exposure to carcinogenic heavy fuel oil much less for the engine room personnel.

The personnel on M/T Tärnholm (and on all of the ships of Tärntank Rederi AB) has passed an education and instruction on the health danger of the heavy fuel oil and the risks of getting it on the skin. It is important to protect yourself by for example always using dense handgear or gloves when in contact with HFO.

Bilge water treatment

Generally a large number of different cleaning agents are used on board a ship. This creates complex mixtures of oil and water – so called stable emulsions – that are hard to separate in traditional bilge water separators. For the rough cleaning in the engine room of M/T Tärnholm a limited number of products are used. Aromatic solvents are avoided to a large extent by using Ultra Sonic Cleaning for heavily greased machine equipment.

For the bilge water separation into oil and water M/T Tärnholm uses a JOWA 3SEP oily water separator combined with a JOWA EBU emulsion breaker unit. The oil content of the discharged bilge water is < 5ppm.

The handling of external hydraulic fluids on board is significantly reduced by choosing electrical equipment for the seven large cargo pumps (Svanehöj). This minimizes the spill both to the environment and to the bilge water. It also creates a working environment of low noise.

Health risks of heavy fuel oil

The marine heavy fuel oil (HFO) is a residual fraction from crude refining and it may contain between 6-20% polycyclic aromatics (PCA). The exact amount is partly depending on the origin of crude but above all on the refinery process. Due to the PCA all HFOs are classified as Carcinogenic Category 2 according to the EU Dangerous Sustance Directive, and should be labelled with a skull and crossbones.

Studies have shown that engine room personnel on ships run an increased risk of getting cancer in the lung and in the urinary bladder. Exposure of marine residual fuel to the skin shows a relatively immediate absorption of carcinogenic polycyclic aromatics into the human body and that these also react with the genetic material. (Nilsson et al)

Everyone working in the engine room must have a clear understanding that the HFO in the long run is very dangerous to the health. No oil should get in contact with skin and correct protective equipment, such as nitrile rubber gloves, should be used. For the future it is urgent to develop non-carcinogenic fuels.

Reduced antifouling

A conventional copper based controlled depletion polymer (CDP) antifouling is used for the hull. A non-toxic epoxy coating is applied, however, between the load mark and the lowest water level. This constitutes about 30% of the coated hull where antifouling is avoided.

For protection coating above the load mark a ”system painting concept” is applied. It refers to a complete system from metal cleaning and rust protection primer up to the topcoat where all components are fitted to each other. This creates a strong and endurable shield. Little maintenance painting is needed and consequently a low exposure of strong solvents for the crew. No heavy metals like lead or chromium are accepted in these coatings.

Clean cooling water

The cooling water system for the engine is sensitive to corrosion and a failure of the system may highly endanger the safety of the ship. To avoid corrosion toxic substances are added to the cooling water. These substances may lead to hazardous exposure of the crew and in the long run end up in the sea. M/T Tärnholm has installed a non-toxic device with magnesium electrodes for the cooling water system. The corrosive free oxygen in the cooling water gets reduced to innocuous magnesium hydroxide.

Elysator

The device is a magnesium electrode constantly liberating magnesium ions. The principle is to reduce the corrosive free oxygen to an incorrosive hydroxide. A reaction takes place at the electrode like the following:
$Mg^{(2+)} + ½\ O_2 + 2H_2O \rightarrow Mg(OH)_2 + H_2O$.

The magnesium hydroxide is innocuous and results in a pH stabilisation around 9.5. This has proved effective both in cooling water systems and as boiler water treatment.

Toxic substances avoided by this magnesium electrode may be hydrazine, morpholine, other volatile amines, hydroquinone, carbohydrazide, methyl ethyl ketoxime, sodium nitrite, chromium compounds etc. (DREW)

Emulsion breaker unit.

Oil separators

Marine gas oil

Heavy fuel oil

Thyristor pump

Elysator

Ultra Sonic Cleaner

M/S STENA SCANDINAVICA

M/S Stena Scandinavica *is a passenger ferry built in 1988 by Stocznia in Gdansk, Poland. The ship was reconstructed in 1996 and 1999. She operates regularly between Göteborg and Kiel in Germany, and is owned by Stena Line in Göteborg. M/S Stena Scandinavica has a sister ship – M/S Stena Germanica – operating the same route.*

M/S Stena Scandinavica has after reconstruction a length over all of 175 metres, a beam of 30 metres and a moulded draft of 6.7 metres. She can take 1700 passengers and 590 passenger cars. There is a total of 1628 load metres on board. The gross tonnage is 39,169.

Low sulphur exhaust

Clean fuels

M/S Stena Scandinavica has two main propellers driven by four Sulzer ZA 448 four-stroke engines of 7360 kW respectively. Auxiliary engines are five Sulzer ASL 25 of 1200 kW each. The main engines are run on low sulphur heavy fuel oil (HFO 380, < 0.5% S). The HFO is produced in a "straight run" refinery process which today is "best choice" of HFO when it comes to carcinogenic polycyclic aromatics (PCA ~7%). Maximum speed is 22 knots and the consumption HFO is about 50 m^3/24 h.

The five auxiliary engines run on marine gas oil < 0.3% sulphur. The consumption is around 10 m^3/24 h.

Shore-side electricity

Already in 1990 M/S Stena Scandinavica got shore-side electricity equipment installed on board and at berth in Göteborg. 11 kV is transformed on shore down to 400 V and then cabelled over to the ship. A difference to the high voltage system used on M/V Schieborg is that M/S Scandinavica does not have to carry around and have the space for a transformer of ~5 tonnes. On the other hand – and that takes precedence – a high voltage cable is much easier to handle and gives more freedom placing the ship at berth.

About 10-15 minutes after the ship is safe at berth the shore-side electricity is switched on and all the auxiliary engines – and the main engines – may be turned off. There are no emissions and no noise from the engines during the ten hours when M/S Stena Scandinavica is at berth in Göteborg. In Kiel however there is no shore-side equipment at quayside. Read more on shore-side electricity under M/V Schieborg.

Energy saving

M/S Stena Scandinavica is a passenger ferry and as such she has large spaces to comfortize with heating, chilling and humidifying. This is mainly powered by the auxiliary engines which generally are more powerful on a ship like this than for example on a cargo vessel. However most of the passenger spaces are only intermittently used. For many hours the dining halls, the cabins, the discoteques and the bars do not have to be comfortized. Here is much energy to be saved – especially in the summer.

M/S Stena Scandinavica has installed frequency transformers linked to time programs for the different spaces to be comfortized. At times when nobody is using an area the frequency is radically lowered and then raised again in due time before use. By for example going down in frequency from 50 Hz to 45 Hz you may gain about 80% of the energy input. For the devoted; it is important that the cosine go from ~0.70 to just under 0.90 which is very efficient reflecting the whole power supply system. On a yearly basis a reduced auxiliary engine fuel consumption of 10-15% is calculated for this measure.

Bilge water treatment

On a ship there is usually large amounts of water ending up in the keelson – most often in connection with cleaning. Here it gets mixed with oils, cleaning agents and other chemical spills from activities on board. These mixtures hardly separate into oil and water in the traditional gravimetric bilge water separators commonly found on board. To get a clean bilge water to discharge overboard an active emulsion breaking system is needed.

M/S Stena Scandinavica was one of the first ships to install an active bilge water treatment system. This is due to that one of the pioneers in developing the Marinfloc emulsion breaking system in Sweden worked in the engine room on Stena Scandinavica at one time and made some of the system testing there.

The Marinfloc system is based on adding a flocculating agent for emulsion breaking and oil separation, followed by activated carbon and sand filtering. This is more thoroughly described under M/S Manon. The Marinfloc concept also includes the exclusive use of tested and approved chemicals for good oil/water separation in the engine room.

As this was one of the first Marinfloc systems installed, it could only be guaranteed oil levels in the bilge water below 15 ppm. Testing has shown that today in reality it is far below that.

Alternative cooling water treatment

To avoid corrosion in the engine cooling water, compounds hazardous for man and environment are usually added to the cooling water system. In the long run these may well end up in the sea. On M/S Stena Scandinavica a non-chemical based system called Spirovent is used for the low-temperature engine cooling water since a number of years with good results.

The principle of Spirovent is that a velocity change is created for the passing cooling water, allowing air to break free of the flow path. The unit eliminates the free air, the entrained air and most of the dissolved air and thus reduces the corrosion risk. On M/S Stena Scandinavica the Spirovent is also installed on the AC-system.

To avoid macrofouling by primarily mussels in the sea chests for e.g. the outer cooling water system and the fire pumps, very harmful chemicals like dithiocarbamates are traditionally dosed in these intakes. On M/S Stena Scandinavica copper-iron electrodes are installed in all nine sea chests. A small amount of copper is released. The release is adjusted to water temperature as mussel adhesion and growth strongly correlates with this. Below 10°C the mussels do not spawn and hence do not liberate any larvae.

Boiler water chemicals

Boiler water is usually treated with toxic substances to prevent corrosion and deposits in the boiler water system. The steel material in the system might otherwise erode from the inside with devastating consequenses. Among others the carcinogenic substance hydrazine and volatile amines with negative health effects are used. Boiler water can leak into the bilge water. It may also be discharged direct into the sea when top or bottom blowing of the boiler.

On M/S Stena Scandinavica only pH-adjusting caustic soda (NaOH) is added to the boiler water system. The consumption is about 0.5 kg/month. In this case it has proven sufficient to prevent corrosion and at the same time maintain low health/environmental danger. By not using volatile, harmful substances in the boiler water it is also possible to use steam from the boiler in spaces where passengers or personnel are dwelling.

Biodegradable hydraulic fluids

Hydraulic fluids on a ship are sometimes used externally or in other spaces where a leakage might lead to spill into the sea. Hydraulic fluids are traditionally based on a mineral oil degrading slowly in cold waters and additives often toxic to the marine environment.

On M/S Stena Scandinavica a change-over has started to biodegradable hydraulic fluids in sensitive applications. So far the hydraulic fluids to the side doors of the ship is being changed to products that fulfil the voluntary environmental criteria of the Swedish technical standard SS 155434.

400V connection

Dosing equipment, boiler

Spirovent

Frequency transformers

Hydraulic piston for side door

Marinfloc filters

Emissions at sea

While air pollutant emissions of SO_2 and NO_X from land-based sources gradually are decreasing, those from shipping show an increase. Even after the MARPOL limits of 1,5% sulfur in marine fuels has been implemented in the North Sea, the Baltic Sea and in the English Channel, emissions are expected to increase. Some calculations show around 40% for SO_2 and about 65% for NO_X between the year 2000 and 2020 in European waters.

It is also calculated that in 2020 the emissions of SO_2 and NO_X from international shipping around Europe will have surpassed the total from all land-based sources in 25 EU member states if nothing more is done.

An estimation is that about 90% of the total SO_2 and NO_X emissions from ships in the North Sea including the English Channel, emanates from a zone of approximately 50 nautical miles (~90 km) from the coast line. (IIASA) (Tsyro, Berge)

New differentiated fairway dues in Sweden.

In january 2005 Sweden revised its system of differentiated fairway dues. The differentiation is based on emissions of nitrogen oxides (NO_X) and sulphur dioxide (SO_2) and the system got somewhat strengthened. Today there is a discount starting at 10 g NO_X/kWh going down to a maximum under 0.5 g NO_X/kWh. For sulphur the due is based on the content in fuel and there are now four levels for taxation 0-0.2%, 0.21-0.5%, 0.51-1%, >1%.

The fairway due is built on two parts where one is based on loaded and unloaded goods and the other on the ships gross tonnage. The latter part is calculated as a standard due minus the NO_X discount per gross tonnage plus the sulphur due per gross tonnage. The dues and discounts per unit ship gross tonnage differs between passenger vessels, cruise vessels, oil tankers and other vessels. (Swedish Maritime Administration)

Oil spills

Large oil spills at sea have got most attention when it comes to environmental problems with shipping. Beside the big tanker accidents there are other problems that are at least as serious. Still after more than 25 years of conventions and regulations there are more or less deliberately continuous discharges of tank cleaning waste, sludge and oil containing bilge water in the Skagerrak, the Kattegatt and in the Baltic Sea.

The discharges are devastating for the seabirds. For example almost the whole population of long-tailed ducks stay in the south of the Baltic Sea during wintertime. They are primarily feeding on sea mussels. The big fairways pass close to the mussel banks though. The long-tailed ducks easily misjudge an oil discharge as being calm water – with disastrous consequences. Every year over 100,000 long-tailed ducks die on Hoburgs bank because of oil discharges.

An important technical reason for the continuous oil discharges is that most of the large ships of today lack a well-functioning oil separation of the bilge water. The usual equipment on board is simple gravimetric bilge water separators which are not capable to break the stable emulsions formed when waste water is mixed with engine oils, gear oils, stern tube oils, degreasing agents, lubricant grease, cleaning agents etc.

M/V MANON

M/V Manon *is a Pure Car Truck Carrier (PCTC) built in 1999 at Daewoo, Korea. She was elongated in 2005 by 28 metres. M/V Manon is owned by Wallenius Lines in Stockholm and operated by Wallenius Wilhelmsen Logistics. She regularly calls at the Port of Göteborg but operates all over the world. M/V Manon has four sister ships: Undine, Elektra, Mignon and Boheme.*

M/V Manon has a lenght over all of 227.9 metres, a maximum draught of 11 metres and a moulded beam of 32.3 metres. The deadweight is 28,126 tonnes and the gross tonnage is 67,264. M/V Manon has a capacity of 7200 cars or 3700 cars and 600 trucks on a maximum of 13 car decks.

The main engine is a KHIC Man B&W, type 8S 60MC two-stroke marine diesel with a capacity of 14,700 kW at 101 rpm. For the electrical power supply there are two auxiliary diesel engines type Wärtsilä 4R32, each attached to an AC generator with a capacity of 1400 kW (3x440 V, 60 Hz) and a 950 kW shaft generator. There is also an emergency diesel generator with a capacity of 165 kW.

Clean fuels at berth and overseas

M/V Manon runs her auxiliary engines – and the emergency engine – on marine gas oil (MGO) with a sulphur content < 0.2%.
The main engine is currently run on low sulphur heavy fuel oil LS HFO 380. During 2005 the average of the whole Wallenius fleet was 1.12% S – on a world basis.

NO_X emission reductions

M/V Manon has – like on all ships in the Wallenius fleet where it is possible – swapped the main engine fuel injection valves for slide valves. This yields a more controlled combustion process with lower temperature peaks. The resulting NO_X reduction is estimated at around 25% to a level of about 12 g NOx/kWh from the main engine.

M/V Manon has also installed humidification technology on the auxiliary engines in order to reduce NO_X emissions. A Wetpac Humid system is attached to the engines where pressurized fresh water is added to the intake air after the turbocharger compressor. Due to the high temperature of the compressed air, the water evaporates immediately and enter the cylinder as steam, thus lowering the combustion temperatures and the formation of NO_X. The NO_X emissions from the auxiliary engines have decreased from 10.9 g/kWh to 6 g/kWh at 80% engine load.

M/V Manons sistership M/V Mignon has installed a Scavenging Air Moisurisation equipment (SAM) on the MAN B&W main diesel engine. It follows the same principle to humidify the scavenging air before the combustion chamber, in order to prevent high temperature peaks with high NO_X emissions. In this case sea water is used, as large amounts of water is required. Due to the water vaporisation no salt contaminants are added to the process. SAM is giving 40-50% NO_X reduction, in this case resulting in an emission level around 6-7 g NO_X/kWh. If the experience from M/V Mignon is good with this technique it will also be installed on M/V Manon.

Advantages with these humidification technologies are that no extra chemicals are needed, there is less wear of the engine, there is no increased fuel consumption and no major rearrangements in the engine room has to be done.

SO_X emission abatement at sea

In the IMO regulation MARPOL Annex VI the North Sea is designated as a Sulphur Emission Control Area (SECA) coming into full effect in november 2007. The regulation covers all shipping activity and at least one of the following options shall be fullfilled:

- ***The sulphur content of fuel used on board shall not exceed 1.5% m/m***
- ***An approved exhaust gas cleaning system shall be installed for all propulsion engines and reducing the total emission of sulphur oxides to 6.0 g SO_X/kWh or less. No adverse effects of waste streams into enclosed ports, harbours and estuaries may occur. This must be thouroughly documented.***
- ***Other verifiable and enforceable technological methods of equivalent sulphur reducing effect as mentioned above, shall be installed. (IMO)***

NO_X emission abatement

In the IMO regulation MARPOL Annex VI the engines installed – or engines which undergo major conversions – after the 1st of January 2000 have to comply with NO_X emission restrictions. The regulation limits are 17 g NO_X/kWh at engine speed up to 130 rpm and successively decreasing with higher engine speed down to 9.8 g/kWh from 2000 rpm.
An elderly ship using standard heavy fuel oil in its main engines may well emit up to 17-20 g NO_X/kWh at 130 rpm. There are several ways of lowering these emissions – at varying costs and with different reduction results. NO_X is formed by N_2 and O_2 in the air during the combustion process. The nitrogen content in the fuel is of minor importance. Principally you can either prevent NO_X forming or perform post combustion conversion back to N_2 and H_2O – or you could do both.

By internal modifications of existing engines there is potential of about 20% NO_X reduction. These are measures trying to prevent NO_X forming and may include for example design of the gas flows into the cylinder, design of valve timing and timing of fuel injection. Other abatement alternatives are the humidification technology mentioned above and the selective catalytic reduction mentioned under M/V Schieborg. (IMO)(Wärtsilä)(Acid News)

Wetpac H

Products on the "White list"

Elysator

MarinFloc EBBWCS

HFO

Marine fuels quality

A problem for ship-owners today buying fuel in large bunker ports all over the world is to really know what they are paying for. This information becomes available only two days later – provided an analysis has been carried out on behalf of the ship-owner. Not uncommon is that fuels fail to comply with the ISO Fuel Standard (ISO 8217). Sometimes hazardous waste like used motor oils or other chemical compounds are mixed in the fuels. This might also have serious safety aspects as for example the manoeuvrability of the ship could be endangered.

M/V Manon – like all Wallenius ships – carefully follows the bunker analysis made by Det Norske Veritas (DNV) and reacts with legal action if possible, if the bunker delivery is not in compliance with the standard. A problem is that damage might already been done – the ship is out on the ocean using the fuel. A solution would be an international marine fuels quality directive – like the one already existing for road vehicle fuels within the European Union. Here fuels are officially standardized and controlled already at the point of sale.

"Wallenius white list"

A ship is like a small society and many of the functions and chemicals found on shore are also found on board a ship. The chemical products used generally do not disappear but end up in the waste, in the bilge water or – if it comes to the worst – in the sea. The large number of different chemical components also makes the waste water mixtures difficult to treat.

On M/V Manon – like on all Wallenius ships – stringent criteria are set up for the chemical products in use. The demands are for example: full information on what components are included; the components must be biodegradable; the components must be non-toxic for both man and environment; and the components must not create stable emulsions in the bilge water tank. The so called "Wallenius white list" for approved chemical products is compiled on the basis of this criteria.

"Green" lubricants

Oils and lubricants are products of special interest. Traditionally they are feared pollutants from ships as they might cause much harm to the marine environment. The stern tube may be a significant source of oil leakage into the sea. This is earlier described under M/V Schieborg. In case of a leakage from the double sealed tube, M/V Manon is using a biodegradable stern tube oil (Vickers Hydrox Bio 68). This oil is also capable of "swallowing" a certain amount of water if there should be a leakage into the stern tube.

Wallenius has also a general policy that when external hydraulic fluids are changed, the new oils shall be biodegradable products that fulfill the environmental criteria of the Swedish technical standard SS 155434. In this standard there are demands on for example rapid biodegradation and low toxicity from additives. M/V Manons sister ship M/V Undine has biodegradable oil in her large stern ramps.

Bilge water treatment

A study made in the Port of Göteborg in 1999, showed that 90% of the ships calling at the harbour did not have a well-functioning oil separation from bilge water. The large number and complex mixtures of chemical components create stable emulsions in the bilge water tank, which are very hard to break in traditional gravimetric separators. Many oils and lubricants for example contain additives that are contributing to stable mixtures.

Due to international regulations ships with a gross tonnage over 1000 shall have oil control equipment and alarm, stopping bilge water discharge containing more than 15 ppm oil. M/S Manon has installed a Marin Floc Emulsion Breaking Bilge Water Cleaning System. The oil content in discharged bilge water is < 5 ppm.

M/V Manon has also installed a so called "white box" which performs a continuous measurement of oil discharge (ppm) and position (GPS). If the oil discharge exceeds 5 ppm in the bilge water the outlet is closed. This is an extra safety measure. Moreover if there is an oil spill found at sea, and M/V Manon is in the vicinity, she can confirm her innocence.

Alternative boiler and cooling water treatment

Boiler water and cooling water treatment agents are different types of substances added to protect boilers and cooling systems from corrosion and deposits. The reactive and carcinogenic substance hydrazine is traditionally added to the boiler system. Other substances with negative health effects like volatile amines are also common.

Sodium nitrite with alkali, borate, chromate salts and aromatic azoles are often added to the cooling water. Carcinogenic nitrosoamines might be formed if cooling water and boiling water get mixed. Both boiling water and cooling water might finally end up in the sea.

M/V Manon has installed Elysator, performing cathodic protection for both cooling water and boiling water with good results. By liberating magnesium ions from a electrode in the water the corrosive free oxygen is reduced. The formed magnesium hydroxide is without harm.

Antifouling

For environmental reasons there is a global ban to paint the hull of a ship with tin-organic antifouling (tributyltin – TBT). Most common is to use copper based antifouling instead, boosted with organic biocides like chlorothalonil, diuron, triazines, isothiazolinones, zinc pyrithione etc. These components are all undesireable in the marine environment and the well-functioning low or non-toxic solutions has yet to come.

Low fouling on the hull is important for economic and environmental reasons. An increased roughness of 0.025 mm on the surface of the hull may lower the speed by 1%. On M/V Manon a promising test is conducted on three test areas of the hull, covered with hard glass platelets in a resin matrix. The coating Ecospeed contains no toxic components. The fouling may be brushed off with regular intervals and under controlled forms.

Bilge water treatment principle

After the traditional gravimetric separation tank, the bilge water is pumped into a reactor tank where a flocculating agent is added. This may be an aluminum chlorohydrate. The flocculating agent breaks the oil/water emulsion and adheses the oil. The flocculate settles slowly and free oil raises to the surface.

After 30-60 minutes the reaction and sedimentation is finished. The oil in the top of the reactor and the flocculate are led to the sludge tank. The water-phase in the middle is filtered through sand and activated carbon and after passing the oil measurement control, it is discharged into the sea. The oil content is guaranteed to be less than 5 ppm.

M/T FOX SUNRISE

M/T Fox Sunrise *is a tanker for oil products and bunker fuel, built at Aas Mekanisk Verksted, Norway in 2005. It is owned by BRP Shipping AB in Västra Frölunda situated just south of the Port of Göteborg. The ship is chartered by Stena Oil AB in Göteborg and is operating over an area from Mongstad in Norway to Poland by the Baltic Sea. M/T Fox Sunrise is regularly calling at the Port of Göteborg.*

M/T Fox Sunrise has a length over all of 69.95 metres, a beam of 13.2 metres and a moulded draught of 6.15 metres. The deadweight is 3364 tonnes and she has a cargo load capacity of 3130 m³, divided into 2840 m³ for heavy fuel oil and 290 m³ for marine diesel oil. She is equipped with both double skin and double deck.

Diesel-electric propulsion
M/T Fox Sunrise has a diesel-electric propulsion system. There are five Scania DI 16 44M four-stroke engines giving 440 kW respectively at 1400-1800 rpm. On each engine there is a Stamford generator giving power to the two 750 kW Veth VL-1250 propellers in the stern and one ”take me home” bow thruster Veth 3-K-1200 on 350 kW. M/T Fox Sunrise has a maximum speed of 12 knots.

The propulsion is lead through the hull vertically. The main propellers may be turned in any angle around 360° and the bow propeller around 180°. This gives M/T Fox Sunrise excellent manoeuvrability which is an important safety feature not least when delivering bunker fuel at sea. The propellers are connected to two separate systems giving a full redundancy steering.

An advantage with the diesel-electric system is the possibility not to use more power – and thus no more fuel – than you actually need at the moment. A Power Management System (PMS) is regulating the engines to turn on and off, based on the power demand. No auxiliary engines are installed – everything is powered by the five diesel engines.

With the diesel-electric system there is also more freedom in placing the engines and the generators on the ship. It does not have to be in the immediate vicinity of the propeller shaft. M/T Fox Sunrise got over 10 % more cargo space than if a conventional propulsion system would have been chosen. The engines and generators are also placed inside boxes for low noise in the engine room and – in case of fire – for safe and quick extinguishing with a high fog system.

Low sulphur gas oil
The Scania diesel engines all run on marine gas oil (MGO) with a sulphur content < 0.1%. All energy produced on board including the thermal oil system for heating cargo (1500 kW) is fuelled by the MGO. M/T Fox Sunrise has a fuel oil tank of 83 m³ which is bunkered every second or third week.
Common rail fuel injection is installed in the engines. This system keeps the fuel at permanent pressure in an accumulator (rail). Solenoid valves inject the correct amount of fuel into each cylinder at the right time. This leads to a higher power output, lower fuel consumption, lower emissions and less visible smoke than if conventional injection is used.

The actual NO_x emissions from the engines are measured to 9.8 g/kWh. This complies with the emission limits of MARPOL Annex VI.

Clean fuels

Energy saving
On M/T Fox Sunrise the cargo tanks for diesel oil are placed just beneath the deck covering the heavy fuel oil tanks. This creates a ”thermos-effect” to the ship as it also has a double skin.

Heavy fuel oil has to be kept at around 50°C during transport to be able to be pumped. A rule of thumb is that HFO looses 1°C an hour in a conventional tanker and therefore has to be heated with a thermal oil system. During a standard transport for M/T Fox Sunrise of approximately six hours, no heating is needed unless extreme cold conditions prevail.

Scania diesel engine

Thruster

”Take me home”

Bunkering control equipment
M/T Fox Sunrise has SAAB Rosemont Tank Radar system installed on all cargo tanks – earlier described under M/T Tärnholm. There is an overfill warning system attached to the tank radar with ”high” alarm at 95% tank volume and a ”high-high” alarm at 98% tank volume. M/T Fox Sunrise is generally loading bunker at berth.

Delivering the bunker fuel might be a completely different story as this is often done at sea to large vessels passing in or out of the Baltic Sea – sometimes during coarse conditions. However M/T Fox Sunrise fully comply with the demands of the project ”Green bunkering” which was succesfully carried through in the Port of Göteborg 1998.

No bilge water overboard
On M/T Fox Sunrise there is a low demand for water/chemical cleaning, mainly due to that HFO is not used as fuel and no maintenance on separators is needed. Fuel filters for the MGO is just exchanged over time. A bilge water tank is installed but no bilge water is discharged overboard. Oil spill is led to the sludge tank of 9.4 m³.

Box cooling
No sea water is taken into the ship for cooling. Two cooling boxes are used instead, through which engine cooling water coils are passing. Still those cooling boxes are open to the sea and macrofouling like mussels must not hinder the water passage by the coils. Copper electrodes are used in the cooling boxes, liberating small amounts of copper ions to prevent macrofouling.

No boiler water chemicals
On M/T Fox Sunrise there is a thermal oil heater on 1500 kW installed for heating the HFO cargo. The heater runs separately on MGO. Water is heated by the diesel engines. There is no need for a boiler and hence no toxic boiler water chemicals.

Prepared for other cargo
To be able to transport more volatile organic products, M/T Fox Sunrise is prepared for vapour recovery at loading. This gives a flexibility to have an environmentally sound transport of other cargo.

Boom

Tank radar

Fuel filter

Box cooler

Vapour recovery

The ”Green bunkering” project of Göteborg

Göteborg is a large bunkering harbour and delivers around 1.5 million tonnes bunker fuel each year. 0.5 million tonnes is bunkered at sea outside Göteborg in specially defined areas. At very rough weather you have to take the ships to more sheltered waters. The largest amounts are bunkered at berth.

In connection with a bunkering operation in 1998 there was an serious oil spill in the archipelago outside the Port of Göteborg. This acted as an alarm-clock for many fuel suppliers, bunker ships, the Coast Guard, the Swedish Maritime Administration, the regional environmental authorities and the Port of Göteborg.

A cooperation project started involving all parties concerned, with the aim to get as safe handling as possible of the bunker fuels in and outside the Port of Göteborg. A number of detailed criteria were agreed upon, for example:

- ***a good communication system between the bunker ship and the recieving ship***
- ***safety equipment for oil spills on the bunker ship***
- ***hydrostatic tests of fuel hoses***
- ***compulsory vetting of bunker ships***
- ***level controls in cargo tanks on bunker ships***
- ***at least two persons at every bunkering operation must have passed an education on safe bunkering and oil spill handling.***

A bunker ship that operates within the Port of Göteborg has to comply with these criteria and do hereby get a bunker licence or the ”green bunker card” by the Port of Göteborg. Misconduct may lead to withdrawal of the bunker licence.

The fuel suppliers are only contracting bunker ships with the green bunker licence and currently all the 25 bunker ships in the Port of Göteborg hold the licence. The over-bunkering incidents have decreased markedly and in the year 2004 the ”zero-vision” was achieved.

Read more

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Mjölskär on the Swedish west coast
Photo: Bengt Frizell

Projekt Grön Kemi is commissioned by Region Västra Götaland, Västra Götaland County Administration, Gothenburg Region Association of Local Authorities and Business Region Göteborg. The object is to stimulate a development towards health and environmentally adopted chemical products which – at the same time – show a good technical performance.

The Projekt has been involved in the development of environmentally adapted hydraulic fluids and lubricant greases in Sweden, the enhanced use of low-toxic solvents and additives in house paints, catalysing a change-over to alkylate petrol for 2-stroke outboard engines in pleasure boats, participating in a ”green bunkering” project for ships and initiating a European Union ban on carcinogenic high-aromatic oils (HA-oils) in tyres for cars. Projekt Grön Kemi has also published a study on clean shipping in 2003 – ”Rent skepp kommer lastat.”

More on Projekt Grön Kemi can be found on www.gronkemi.nu

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