**SEWAGE TREATMENT PLANT**

The IMO’s MARPOL Annex IV Convention, which aims at achieving the prevention of pollution by sewage from ships, was developed in the 1970s, and entered into force since 2003. It contains a set of regulations prohibiting sewage discharge from ships, unless via an approved sewage treatment plant, via a comminuting and disinfecting unit (CDU) at a distance of more than three nautical miles from the nearest land, or to the open sea (> 12nm) while en-route at not less than four knots. Sewage can also be offloaded to port reception facilities.

Discharging sewage to the open sea is simple and free, but it entails extra storage tanks, reduced flexibilities and it implies a somewhat negative image for the shipping line. CDU’s are primitive and rarely employed by ships sailing internationally. The harmful by-products from CDU’s have also prompted further reviews (MEPC 71/14/2). Sewage port reception facilities have gained regional attention, but issues such as availability, adequacy and fee structures have hindered their widespread adoption. It is easy to see, therefore, that sewage treatment plants have proven to be the popular option.

The Marine Environmental Protection Committee (MEPC) has developed guidelines on sewage treatment plant effluent standards and performance test specifications. These effluent standards are ambitious compared to those of equivalent coastal discharges ashore. For example, a sewage treatment plant for a 12-passenger ship trading in the Baltic Sea is given similar Total Nitrogen limits as that of a municipal wastewater treatment plant serving > 10,000 people, while sewage discharges from a decentralized 12-person community around the Baltic Sea does not have Total Nitrogen limits. In fact, a better-informed wastewater industry ashore considers applying such Total Nitrogen limits to a community of up to 300 people to be neither viable nor beneficial (BSAP, 2008).

At the same time, there is no shortage of approved sewage treatment plants that are low-cost and “care-free.” The marine industry seems to cope swimmingly with what are seemingly impossible targets for other industries. The MEPC has tightened the effluent standards twice in 10 years. In the meantime, sewage treatment plants often became smaller and cheaper.

MARPOL Annex IV has no compliance monitoring, and no enforcement protocols. How the sewage treatment plant is actually functioning, no one knows, nor needs to know. In fact, Annex IV does not request operational sewage treatment plants on board to meet any concentration limits.

Sewage includes:

 - drainage and other wastes from any form of toilets and urinals

 - drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises

 - drainage from spaces containing living animals; or

 - their waste waters when mixed with the drainages defined above.

Holding tank means a tank used for the collection and storage of sewage.

BLACK WASTEWATER

Collected due to leaks of water, oil, and fuel from the main and auxiliary engines, as well as other equipment on ships in the engine room. Such waters are treated with special devices required by MARPOL, bilge water separators (Waste / oily water purifier), which must provide purity of 15 ppm.

Separators work on the principle of separation, ie filtration of wastewater so that heavier fractions are separated and collected at the bottom, from where they are transferred back to the collection tank, from where they are transferred by a special transfer pump via the International Deck, to collection facilities onshore, tankers or ships.

GRAY SEWAGE WATER

Collected from toilets, showers, kitchens, and cabins, which are stored in special collection tanks. According to the requirements of MARPOL, they must be treated in special devices (separators) and after treatment, clean water can be discharged into the sea, and the waste residue must be burned in special devices, called incinerators. The special treatment of these waters is regulated by the requirements in Annex IV.

MARPOL has prescribed in its Annex (IV) how Gray wastewater can be discharged directly into the Sea and at what distances from the shore as well as at what speeds, for example, a minimum of 12 nautical miles from the shore at a ship speed of not less than 4 knots, 4 km/h)

In practice, this is usually done without taking into account the requirements of MARPOL, but according to the condition and contents of the tank when it comes to overflowing and unpleasant odor.

**Gray water connection to disinfection stage**

Incentivised by the classification societies’ green notations, many shipowners have taken the initiative to treat gray water, even if this is not required by the IMO. The sewage treatment plant should be suitably sized in order for gray water to receive the same treatment as sewage. However, some sewage treatment plants connect gray water to the last disinfection stage. This means there is non-conformity to MEPC 227(64).

Such sewage treatment plants gain a commercial advantage by “treating” gray water without increasing their sizing. The approved disinfection contact time is invalidated. Gray water pollution is disguised as sewage treatment plant effluent, thus causing poor performance. In an ironic twist, many new ships are awarded for carrying this non-conformity.

**Sewage treatment plant recirculation during a performance test**

MEPC.227(64) requires sewage treatment plant influent to represent raw sewage and prohibits recirculates generated from the sewage treatment plant to be returned to its influent. Otherwise, the influent no longer represents raw sewage, and the plant’s capacity would be overrated. Yet, some conformity assessment bodies have approved precisely these plants. As of now, one market surveillance administration has mobilised its internal procedures to review one possible candidate.

**Chlorination disinfection without de-chlorination**

Chlorination relies on a time-concentration relationship, which has for decades been well understood and documented. With a typical contact time of 30 minutes, a chlorine dose of 5-15 mg/l can effectively disinfect biologically treated effluent (Wastewater Engineering Treatment and Reuse, 4th edition, Metcalf & Eddy). For this concentration to be reduced to below the 0.5 mg/l limit, a de-chlorination step is a must. Yet, the de-chlorination step is absent in some chlorine-based sewage treatment plants. Considering that almost all chlorine-based ballast water treatment plants incorporate a de-chlorination step for less arduous disinfection duty, the inconsistencies between approvals for sewage treatment plants and ballast water treatment systems are beyond comprehension.

**“No-sludge” production**

Some sewage treatment plants do not have provisions to discharge sewage sludge. Such no-sludge claims do not conform to environmental science and are simply untrue. One such sewage treatment plant was even certified to remove Total Phosphorus, in which case the “removed” Total Phosphorus has to disappear into nowhere. Recently, one Notified Body announced suspension of the MED approval certificate of a sewage treatment plant, subject to further reviews. Despite this development, there are still other magic boxes with no-sludge claims, approved by other Notified Bodies, and the issue may still persist beyond the European efforts.

**Silver lining**

Having seen the realities, Alaska regulators took actions starting in the early 2000s. They introduced new rules and the Commercial Passenger Vessel Environmental Compliance (CPVEC) program to the large cruise ships trading in Alaska water each year. Gray water, being more polluted than sewage, was also brought under the same rules.

Some vendors, including Wärtsilä Water Systems Ltd, developed a new generation of technologies known as Advanced Wastewater Treatment Systems (AWTS). AWTS carry the same certificates as sewage treatment plants and marine sanitation devices do, but differ from them in that the ships’ discharges are sampled and monitored under CPVEC, with the results published in the public domain. The success of this program has been praised by all stakeholders, in particular by the cruise industry.

Screen Filter:

The screen filter mesh is fitted on the first tank near the entrance of the sewage to the STP. It helps in removing the non-sewage adulteration component such as; toilet paper, plastic paper, other solids etc, which can clog the complete system if went inside.

Biofilter:

The biofilter is also the part of the aeration chamber which treats the sewage passing from the screen filter. The biofilter reactor, with the help of fine air bubbles supplied from the blower, will disperse the contaminated substance diffusing and breaking down the organic matter by the aerobic microorganism. The fine bubble by passing through the diffuser will increase the oxygen transmission rate.

Settling/ Sedimentation Chamber:

The treated sewage water from the biofilter reactor will come to the next chamber which is used for settling purpose. The mixture will be further separated to high-grade water and sediment after being settled in Sedimentation tank. The clarification compartment is usually of the hopper type with sloping sides which prevent the sticking and accumulating of sludge and send it to the suction side of the air lift tube.

The untreated sludge settled in the bottom of the sedimentation tank returns into the Biofilter reactor to break up by microorganism again.

Activated Carbon:

The activated carbon is fitted post the settling chamber to remove Chemical Oxygen Demand (COD) by filtering and absorption. It also helps in treating the Biological Oxygen Demand (BOD) and Suspended Solids.

Chlorinator:

The chlorinator is fitted in the last chamber to treat the final stage water for discharging overboard. The chlorinator can be of tablet dosing type or chemical injection type. Inside the tablet-based chlorinator, clean water comes directly in contacts with the chlorine tablets, making a chlorine solution. The chlorinator comprises cylinders for filling the chlorinator with tablets.

In chemical pump type, a measured set quantity of NaOCl is injected to sterilization/chlorination tank using the diaphragm type reciprocating pump.

Sewage Treatment Plant

Air Blower:

There are usually 2 air blowers installed, in which one acts as stand-by, to supply air (via air bubbles) helping in forming the microorganism in biofilter reactor. It also helps in transferring the sludge from sedimentation tank, supply air to the activated carbon tank and to back flush the sludge.

Discharge Pump:

The discharge pump is provided in a duplex and they are mounted on the last compartment of the STP. They are centrifugal pumps of the non-clog type which are coupled to their respective motors. The pump is run on auto mode controlled by the level switches installed in the sterilization tank. The pump is usually run on manual mode when taking out the sludge from the compartments after the cleaning of the tank insides.

Piping:

The inlet pipe carrying the sewage to the plant is installed with the proper slope to prevent the clotting and condensation.

The sewage pipe is such arranged that the inside holes are accessible for cleaning during maintenance.

Overboard discharging outlet should be placed 200~300mm lower than L.W.L and the discharge pipe is provided with a Non-return valve.

Floats and Level Switches: Usually, Three float switches, namely – high level, low level, and high alarm level switch are fitted on the chlorination/sterilization chamber.

This chamber is also fitted with level switches to control the start-stop of the discharge pump.

Precautions for efficient operation of STP:

The aeration blower is installed to run continuously as it helps the microorganism to sustain and grow. Never switch off the blower as it will cause the death of microorganisms, which will, in turn, reduce its clarification efficiency and will take days to grow microorganisms again.

Never throw any foreign substances such as cigarette buds, paper, rags etc. into toilets as it may choke the pipeline or filter hampering the STP operation

The toilet tissue used onboard should be free of vinyl components as it affects the growth of bacteria

Never use unauthorized chemical or detergent to clean toilet

The grey water inlet pipe must be placed lower than the water level of the inside of S.T.P to decrease the foam generation

The pH of the samples of effluent shall be in the range of 6 to 8.5

The Nitrite content is not to exceed 10 mg/ltr NO2.

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Working of Biological Sewage Plant:

The basic principle of the working of a biological treatment plant is decomposition of the raw sewage. This process is done by aerating the sewage chamber with fresh air. The aerobic bacteria survive on this fresh air and decompose the raw sewage which can be disposed of in the sea. Air is a very important criterion in the functioning of the biological sewage plant because if air is not present, it will lead to the growth of anaerobic bacteria, which produces toxic gasses that are hazardous to health. Also, after decomposition of the sewage with anaerobic bacteria, a dark black liquid causes discolouration of water which is not accepted for discharging. Thus in a biological sewage treatment plant, the main aim is to maintain the flow of fresh air.

Division of Processes

The biological sewage plant is divided into three chambers:-

Aeration chamber

This chamber is fed with raw sewage which has been grounded to form small particles. The advantage of breaking sewage in small particles is that it increases the area and a high number of bacteria can attack simultaneously to decompose the sewage. The sewage is decomposed into carbon dioxide, water, and inorganic sewage. The air is forced through the diffuser into the air chamber. The pressure of air flow also plays an important role in decomposition of the sewage. If the pressure is kept high then the mixture of air and sewage will not take place properly and it will escape without doing any work required for decomposition. It is for this reason; controlled pressure is important inside the sewage treatment plant as this will help in proper mixing and decomposition by the agitation caused by air bubbles. Generally, the pressure is kept around 0.3-0.4 bars.

Settling tank

The mixture of liquid and sludge is passed to settling tank from the aeration chamber. In the settling tank, the sludge settles at the bottom and clear liquid on the top. The sludge present at the bottom is not allowed to be kept inside the settling tank as this will lead to the growth of anaerobic bacteria and foul gasses will be produced. The sludge formed is recycled with the incoming sludge where it will mix with the later and assist in the breakdown of sewage.

Chlorination and Collection

In this chamber, the clear liquid produced from the settling tank is overflown and the liquid is disinfected with the help of chlorine. This is done because of the presence of the e-Coli bacteria present in the liquid. To reduce these bacteria to acceptable level chlorination is done. Moreover, to reduce the e-Coli, the treated liquid is kept for a period of at least 60 minutes. In some plants, disinfection is also done with the help of ultraviolet radiation. The collected liquid is discharged to overboard or settling tank depending on the geological position of the ship. If the ship is in restricted or near coastline then the sewage will be discharged into the holding tank; otherwise, the sewage is discharged directly into the sea when a high level is reached and is disposed of automatically until low-level switch activates.