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Initial Recommendations for Bilge Oily Water Separator System Design and Operation

ABSTRACT

This paper discusses the problems associated with design and operation of Oily Water Separators (OWS) and provides initial recommendations with regard to OWS system design and operation and proposes areas for further study and investigation.

Oily Water Separator systems, while standard shipboard equipment for over two decades, are just the beginning of many systems that have been and will be installed aboard ships to serve the public rather than the shipowner or crew.

Despite numerous (but often disorganized) efforts, shipboard bilge water Oily Water Separation systems fail to produce satisfactory results for owners, regulators and crews. The failure of these systems is not solely related to technical equipment design issues, but reaches back into human factors, systems design, record keeping methodologies and inspection procedures.

SNAME T&R Ad Hoc Panel 14 is collecting input and suggestions from owners, crews, regulators, ship designers, ship operators and equipment suppliers in a neutral technical forum and is developing recommendations for oily water separator systems that will be regarded as a fully integrated component of the ship system rather than a stand alone piece of equipment.

This paper is an introduction to this subject and in this regard criticism, comments and suggestions from all OWS system stakeholders will further the understanding of this complex subject and are deeply welcomed and appreciated.

INTRODUCTION

The story of Oily Water Separators on board commercial vessels is long, confusing and poorly documented. The panel has made a documentary search on Oily Water Separation papers and publications and the REFERENCE section lists information that is available on the subject.

None of this information provides a complete treatment of OWS systems and many of the papers that are listed are descriptions of commercial improvements of OWS Technology. As near as the panel can determine, Oily Water Separation system design has never been formally analyzed from the bottom up. This paper serves as a starting point of documenting what is known and what is not known at this stage as far as OWS systems and technology is concerned, and provides some specific initial recommendations to OWS system designers and operators.

It is important to note that for the purposes of this paper OWS systems are defined as the entire system that exists aboard a vessel, including people and paperwork. OWS technology, on the other hand, is defined as equipment that can be purchased and installed aboard a vessel to separate oil and water.

Both these subjects will be discussed in this paper, but the OWS system, rather than the technology, is the focus of this paper. Taking into account that bilge water does not consist of just oil and water the term OWS is actually a misnomer and it is suggested in this paper that Bilge Water Processing systems is a more appropriate term.

Before dealing with the analysis of OWS as a fully integrated component of a ship, a general description of OWS technology as it exists today is provided.

OWS TECHNOLOGY

OWS technology is equipment that performs a process that allows the removal of oil from water and that can be purchased from a supplier. On a US flag vessel such a piece of equipment needs to be US Coast Guard approved. The US Coast Guard publishes a list of approved OWS equipment. At present there are approximately 32 manufacturers, each with different types of equipment that are USCG approved. At this stage there is reasonable alignment between US and international regulations and, for the sake of this paper, any comments that relate to USCG regulations will generally apply to non-US vessels as well.

The Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) has published new regulations as part of MEPC 107(49), July 18, 2003, that set stricter performance standards for OWS equipment on new and existing ships. These regulations have come into effect as of January 1, 2005 and a number of manufacturers are providing equipment that has been approved under the new standards. This newer regulation will be discussed in the section labeled **MEPC 107(49)**.

All OWS equipment, new or old, can, in a laboratory setting, separate oil and water, do so automatically, and produce clean water for discharge overboard that contains no more than 15 parts per million oil. OWS equipment is approved by testing it with specific cocktails of mixed oil and water. Initially these cocktails were very simple, basically no more than a mixture of clean water and diesel fuel, but they have become more sophisticated under MARPOL MEPC 107(49).

The vast majority of these many equipment models, manufacturers, and types start with some sort of gravity separation of bilge water, similar to what takes place in oil and vinegar salad dressing. Simply letting oil and water sit is called decanting, and this does not always meet the 15 ppm criterion, which is why each manufacturer has added additional features to his equipment to ensure that this criterion can be met. This paper will not describe all the different methods, but only notes that from a crew's point of view, all these bells and whistles are confusing, especially since on any one ship an engineer will encounter a different manufacturer's OWS, which might or might not use the bells and whistles he dealt with on a prior ship.

The separation that takes place inside the OWS allows oil that floats to the top to be automatically skimmed off to a dirty oil holding tank.

It should be remembered that an engineer rarely encounters more than, say, 10 types of main engines in his professional career and often has been specially trained on those engines, but in his career he might encounter many more types of OWS, none of which he has been specially trained on and none of which he uses more than a few times per month.

An OWS needs to be fitted with an Oil Content Meter (OCM) that samples the OWS overboard discharge water for oil content. If the oil content is less than 15 ppm, the OCM allows the water to be discharged overboard. If the oil content is higher than 15 ppm, the OCM will activate an alarm and move a three-way valve that, within a short period of time, will recirculate the overboard discharge water to a tank on the OWS suction side.

There are also quite a number of approved OCM types and manufacturers, but fortunately, at present, the market is mostly occupied by just a few manufacturers and other manufacturers are only encountered in older systems.

An OCM takes a trickle sample from the OWS overboard discharge line and shines a light through the sample to an optical sensor. Since small oil droplets will diffract and diffuse light, a change in signal at the sensor will indicate the presence of oil. At a certain signal setting that is roughly equivalent to 15 ppm, the sensor will conclude that there is too much oil going though the discharge line. This calibration generally takes place in a lab, but can be tested by use of a sample liquid aboard the vessel. If the OCM ends up sampling a certain amount of heavy oil, the OCM will be fouled and it will need to flushed or cleaned.

The cleaning can be done by running fresh water through the OCM via a permanent connection or can be performed by opening the OCM sample area and scrubbing the sample area with a bottle brush.

The fresh water connection is particularly problematic since it allows the OCM to be supplied with nice clean water while the OWS can be pumping any combination of oil and water through the discharge line without activating the alarm and moving the OWS to recirculation mode.

If the OWS were to receive only a nice mixture of oil and water, the OWS can probably run continuously and indefinitely. Unfortunately engine rooms do not generate nice bilge water and inevitably the OWS will be subjected to various foul and contaminated combinations of oil, water, solids such as rust and soot and oily products heavier than water. Depending on what the bilges collect, the unit may have to be opened for service. Unfortunately this service interval is hard to establish.

To assist the crew, most OWS are supplied with dismal manuals written in poor English with non-standard terminology. In many cases, the manuals do not show the crew what the inside looks like, and often provide unrealistic service recommendations.

One can compare OWS equipment with Fuel Oil Purification equipment, which was also a very difficult piece of equipment to train crews on, but which at least had a very direct risk/reward system. If the Fuel Oil Purifiers did not work, the engine would get damaged and the ship would stop moving. Furthermore, once the dust settled, the number of fuel oil purifier manufacturers could be counted on one hand and crews would not be confronted with a new set of unknowns every time they shifted to another vessel.

It should be noted that there are continuous efforts at improving technologies and on passenger vessels it appears that today there are some technologies and systems that are actually working within the passenger vessel culture. However, it should be remembered that passenger ship culture is easier to change than cargo ship culture since there are more resources and on passenger ships a clean environmental image might actually be profitable (Ref. 1)

HISTORICAL BACKGROUND

Oily Water Separators (OWS) have been used aboard ships for over 20 years and are a regulatory requirement. The international requirements for Oily Water Separators are promulgated under the various MARPOL conventions and aim to prevent discharge of oil to the sea and require ship's crews to keep track of oil movements within the ship and to shore through the Oil Record Book (ORB). (MARPOL 73/78 Consolidated Edition, 2002, chapter II regulations 16 and 20)

Under these regulations just about every ocean going vessel is required to ensure that it does not discharge bilge water containing oil at more than 15 parts per million clean water. This requirement has been adapted into most flag state regulations and as such the presence of Oily Water Separation systems aboard large commercial vessels is the norm. It should be noted that the MARPOL regulations do not specifically require the use of OWS equipment. Under certain circumstances ships could be allowed to store their bilge liquids in tanks and discharge to shore and do not need to have an OWS aboard.

From a regulatory point of view, OWS systems are the vanguard of a host of novel systems that have been and will be installed on ships in the near future.

Some of those systems are:

- Garbage processing systems
- Tank cleaning systems

- Ballast water treatment and exchange systems
- Exhaust emission control systems
- Incinerators
- Closed loading systems
- Sewage and sanitary systems

The main novelty of these systems is that, rather than make the ship more efficient, these systems, from a shipowner and crew point of view, actually make the ship less efficient.

The benefit of these systems is for the public, and, consequently, shipowners and crews have been directed to install and operate these systems for the benefit of the public. This is not an entirely unfair burden, and if all shipowners and crews participate to the fullest possible extent, there is no competitive disadvantage since any additional costs will be passed on to the shippers and, on the next level, to the public.

At the same time, the shipowners have not paid any particular attention to the design of these systems and for the most part have simply taken an attitude that can be best described as: "Tell us what you want and we'll put it on board and we'll have the crew operate it". In many cases the systems were retrofitted and since an efficient system does not give an owner a real competitive advantage, very little thought has gone into the design of these systems.

Ship's crews have had even less participation in the process and they have had to accept whatever equipment is put aboard and simply operate it to a level that is acceptable to the shipowner. If a crewmember discovered that a system did not work, they could tell the owner that the system did not work, and the owner would give them half a promise to do something about it at the next dry-docking, or the owner could make a mental note to make sure he'll get rid of a "difficult" engineer. Often engineers, being engineers, would make changes to the system that were poorly documented aboard the vessel and that, in turn, resulted in further changes and fixes by subsequent engine room crews.

For many years it was assumed that this approach would prevent and reduce oil discharge to the sea, but as far as this panel knows, no systematic analysis of this assumption has ever been performed.

Surveyors are often directed to evaluate the condition of OWS systems aboard vessels for various clients. However, due to the physical design and purpose of these systems, it is almost impossible to arrive at a meaningful opinion of the condition and functionality of an OWS simply by looking at it and inspecting the Oil Record Book.

A surveyor would ask about the OWS, be directed to a piece of equipment that looks like an OWS and would have to determine from the looks of it if this piece of equipment was doing a good job of separating oil and water. If the unit does not look good, the surveyor can ask the crew to turn it on. The Oil Content Meter can be switched on and sometimes the crew will start the unit in a circulation mode. However, even if it runs, that does not mean that the unit is operating properly. A surveyor cannot know what is going inside the OWS and, therefore, cannot determine if any separating is taking place. Often the crew will state that they are not allowed to operate the OWS in port and because all systems are arranged differently it can take much time to determine if this system actually can be tested in port.

A surveyor asked to survey one of these systems could only conclude that it looked like an OWS system and that all the pieces were there and that therefore it probably was an OWS system.

This was a problem for all surveyors and inspectors, and government inspectors started to wonder if any separating actually took place aboard ships. Especially in the last few years, the United States Coast Guard and other port state control agencies have been paying closer attention to the use and misuse of this equipment. Based on their review of this issue and the results of various legal prosecutions it can be assumed that most OWS systems do not work and that owners and crew are pumping massive amounts of dirty bilges overboard.

A simple review of the operators who have admitted to wrong doing with regard to OWS operation clearly shows that the issue is not limited to only substandard operators. Does this mean that criminal behavior with regard to OWS operations is standard in the shipping industry? That question is more difficult to answer and most certainly the newspapers do not tell the whole story.

Based on available information it appears the truth lies somewhere between extremes. Some owners could not care less how much oil goes over the side, and still they have crews aboard their ships who make every effort short of properly operating the OWS in preventing bilge oil from being discharged into the environment. At the same time there could be very conscientious owners who have provided the most expensive equipment to their crews and crews who simply could not care less whether they are pumping oil over the side or not.

As a middle ground it could be suggested that only a very small proportion of people are wanton polluters and most are doing the best they can with a system that, in the end, does not do the job.

This panel has no real proof of any of the above scenarios, but having spent many years in the marine industry with crews, owners and operators from many cultures and nations, the last option might best describe the norm in the industry.

In order to further study this matter, the United States Coast Guard established the Oily Water Separation Task Force and asked for public comment on OWS issues. The public comments that were obtained are listed on the Docket Management system (Ref. 2). The United States Coast Guard never prepared a formal public summarization of the public comments, but they show the wide variety of concerns that are associated with OWS systems.

A summary of those comments is noted in reference 17.

This paper will not deal with the methods used by the US government to prosecute OWS operational offenders. The panel fully and wholeheartedly supports the USCG’s efforts at reducing marine pollution, but notes that the methodologies used to prove foul play rarely result in a clear-cut case. This is not a fault of the USCG, but rather is related to the non-standard design, operation and complexity of the system that is being investigated.

This panel welcomes the USCG’s involvement and experience in the OWS system debate as a partner in arriving at technically efficient and effective solutions.

For guidance on international activities, a general discussion of maritime environmental compliance is provided in “COST SAVINGS STEMMING FROM NON-COMPLIANCE WITH INTERNATIONAL ENVIRONMENTAL REGULATIONS IN THE MARITIME SECTOR” (Ref. 3)

It is noted that the most recent amendments to MARPOL will require additional components on newly constructed vessels, but do not provide any guidance in standardization of OWS system design and operation.

MEPC 107(49) REGULATIONS

The Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) has published new regulations as part of MEPC 107(49), July 18, 2003, that set stricter performance standards for OWS equipment on new and existing ships (Ref. 23).

The new MEPC 107(49) regulation as a part of MARPOL 73/78 regulations are now requiring the following additional features on OWS equipment:

1. MEPC 107(49) certified bilge alarm or Oil Content Monitors, which provides for internal recording of alarm conditions.
2. OCM to be tamper proof

3. OCM alarm to be activated whenever clean water is used for cleaning or zeroing purposes
4. Separator capable of achieving 15 ppm on type C emulsion.

These regulations have come into effect as of January 1, 2005 and a number of manufacturers are presently providing equipment that has been approved under the new standards. This newer equipment needs to be installed on vessels built or retrofitted on or after January 1, 2005

This equipment can, in a laboratory setting, separate oil and water, do so automatically, and produce clean water for discharge overboard that contains no more than 15 parts per million oil.

All OWS equipment is approved by testing it with specific cocktails of mixed oil and water. Initially these cocktails were very simple, basically no more than a mixture of clean water and diesel fuel, but they have become more sophisticated under MEPC 107(49). The primary difference between MEPC 107(49) and MEPC 60(33) is the addition of Part C to the MEPC 60(33) testing standard. Parts A and B of MEPC 107(49) tests are approximately equivalent to MEPC 60(33) consisting of evaluation of OWS performance with heavy fuel oil (Part A) and with marine diesel fuel (Part B).

Part C which is contained in MEPC 107(49) evaluates OWS performance when challenged with a diesel/fuel oil/ fresh water mixture which has been emulsified utilizing mechanical agitation, detergent, solvent and particulate matter, the parameters of which are all exactly specified. Approximately 35% of the emulsion (if prepared as per guidelines) consists of emulsified oily droplets of 0-10 micron. This component of the emulsion will not separate out utilizing gravity separation devices that exploit buoyancy differences between the droplets and water in order to be effective. Therefore this arises the need for post gravity separation treatment.

These newer regulations were developed to allow oil separation from liquid mixtures that contain emulsifiers. Emulsifiers, liquids similar to soap, reduce the ability of oil to separate from water by gravity alone and therefore should ideally be excluded from a ship's bilges since they will cause the OWS to malfunction. Unfortunately it is difficult to predict what type of liquids enter the bilges and often, inadvertently, chemicals that act as emulsifiers end up in the ship's bilges, with resultant problems in bilge separation.

Various new designs have now been developed to deal with the emulsified test liquids. Those units that are approved are capable of separating oil from those emulsified test liquids in laboratory conditions. Unfortunately experience with these test liquids and these improved OWS units indicates that the ability to separate oil from the test liquids is heavily dependent on agitation at the point of entry into the OWS and operating temperatures. If separation of test liquids is a process that requires specific operating conditions, it can be readily concluded that real life liquids will also require specific operating conditions, which in turn makes it doubtful that the newer model are truly automatic.

This sensitivity of these units to the quality of the liquids to be separated and their inherently more complex design is serious cause for concern with regard to actual operation of these units aboard ships by non-expert crews, and as such might not result in actual improvements in OWS system performance.

From a technical point of view with regard to OWS equipment, it appears that at present all manufacturers are using the OWS equipment that had been approved under earlier regulations and have fitted post treatment units such as filters or polishers to deal with the emulsification portion of the test liquids.

THE OWS SYSTEM

An Oily Water Separation system, as compared to OWS equipment, is a wide-ranging system that is not just confined to the vessel, but extends to regulatory organizations and port engineering staff and shore based support contractors. The objective of an OWS system is to separate the oil from bilge water, to pump the clean bilge water overboard and to allow for storage and disposal of the waste oil.

The OWS system contains the following components:

- Bilge water sources
- Bilge water contaminant sources
- Bilge water treatment, including the OWS
- Waste oil storage
- Waste oil disposal
- Oil Record Book (ORB)
- OWS system Operators (Human Factors)
- Regulatory enforcement agencies
- Waste oil receivers/incinerators
- Economic factors

To a large extent the system is linear in sequence and the process roughly follows the order described above, but while linear, in practice, the system is wildly variable (chaotic), intermittent, and unstable.

Bilge Water Sources:

In a perfect ship, no water collects in the engine room bilges and no discharge of bilge water is required. Unfortunately there are no perfect ships and the following is an incomplete list of bilge water sources:

1. Simple condensation from its various sources (cooling equipment, atmospheric condensation, intercoolers)
2. Drains (boilers, sinks, air compressors, fuel oil purification drains)
3. Engine room washdown water
4. Leakage (packing glands, broken lines)

The amount of bilge water that collects in the engine room can vary wildly from cups per day to tons per day depending on the activities that are taking place in the engine room and atmospheric conditions. Draining of a boiler for maintenance can add tons of water to a normally very small bilge water production rate. It is reported that in humid tropical conditions a main engine turbocharger intercooler on a modern ultralarge container ship can produce as much as 50 tons of condensate water per day.

Except for fuel oil purification drains, these sources (if not contaminated) essentially produce clean water that probably would not hold more than 15ppm oil. Still this water should be discharged through the OWS and the OCM. Since OWS generally contain some level of oil, this means that this water is led through a device that contains oil before it is discharged overboard.

Crews often attempt to keep clean water separate, and undoubtedly significant amounts of "clean" water are often pumped overboard directly. One such example would be a through-the-sideshell drain for boilers, which appears like a reasonable arrangement until one considers that especially auxiliary boilers can be severely oil contaminated which can result in discharge of oil containing water to the environment. There is no standardization for boiler drains and therefore crews have no consistent guidance as to how to deal with boiler water if it is potentially contaminated. This shows that water discharge is often a judgment call by the crew.

Tugboat engine room personnel sometimes rig special catch basins under stern glands that drain to a separate container. This container is then directly discharged overboard. Since tugboats are generally only fitted with a slop tank, this reduces the amount of slops that is collected and thereby reduces the number of shore discharges that have to be made. These are water lubricated stern tubes, but there is some lubrication in the glands and it is not clear if this arrangement is correct under the law.

Bilge Water Contaminant Sources:

Bilge water can be contaminated by any material that is present aboard a vessel and that can be pumped as a mixture with bilge water.

The following contaminants are often found aboard a vessel and therefore in the bilges:

1. Old lube oil (from engine and equipment leaks)
2. New lube oil (from spills when filling equipment)
3. Soap (from engine room sinks)
4. Soot (in fine mist from engine exhaust)
5. Soot (in larger particles from boiler cleaning)
6. Bilge, tank and heat exchanger cleaners
7. Fuel oil purifier waste such as water and sludge
8. Fuel oil (from manifold leaks, equipment failure, etc.)
9. Wear products such as found in old lube oil
10. Rust
11. Antifreeze
12. Hydraulic oil (from leaks or filling)
13. Paint chips and residue (from painting activities or paint failure)
14. Solvents (from paints, spills and parts cleaning)
15. Biological contaminant (algae from strainer cleaning, and microbial contamination)
16. Mud (from strainer and equipment cleaning)
17. Sewage (from leaks)

On a properly operated vessel only small amounts of these materials would be present as long as there are no equipment failures. But even the best-operated vessels suffer equipment failures, which then quickly results in contaminated bilges. Sometimes these contaminations are massive and pose a serious challenge to the crew to deal with in a legal fashion.

Bilge cleaners have often been mentioned as a fly in the ointment with regard to OWS equipment operation. Since many bilge cleaners dissolve (emulsify) oil in water the bilge water/oil mixture then becomes inseparable and the OWS will no longer function. Today there are bilge cleaners that can be tolerated in OWS equipment, but only certain cleaners have been certified by certain OWS manufacturers. At this stage there is no indication that there is any one particular cleaner that can clean and will work in any OWS. Often the certified cleaners are difficult to supply to ships and a certified cleaner has often only been tested in laboratory conditions.

Since OWS operate on a gravity separation principle, any contaminants heavier than water will not be separated in the OWS and will end up in the bottom of the OWS and eventually could be pumped overboard. When pumped overboard, these contaminants will sink and not leave an oil slick, but it is possible to create an oily contaminant that is heavier than water by combining the various contaminants found in an engine room. This oily contaminant will also deposit in the OWS discharge line. Soot and oil can make a heavy sludge that poses a real problem to an OWS.

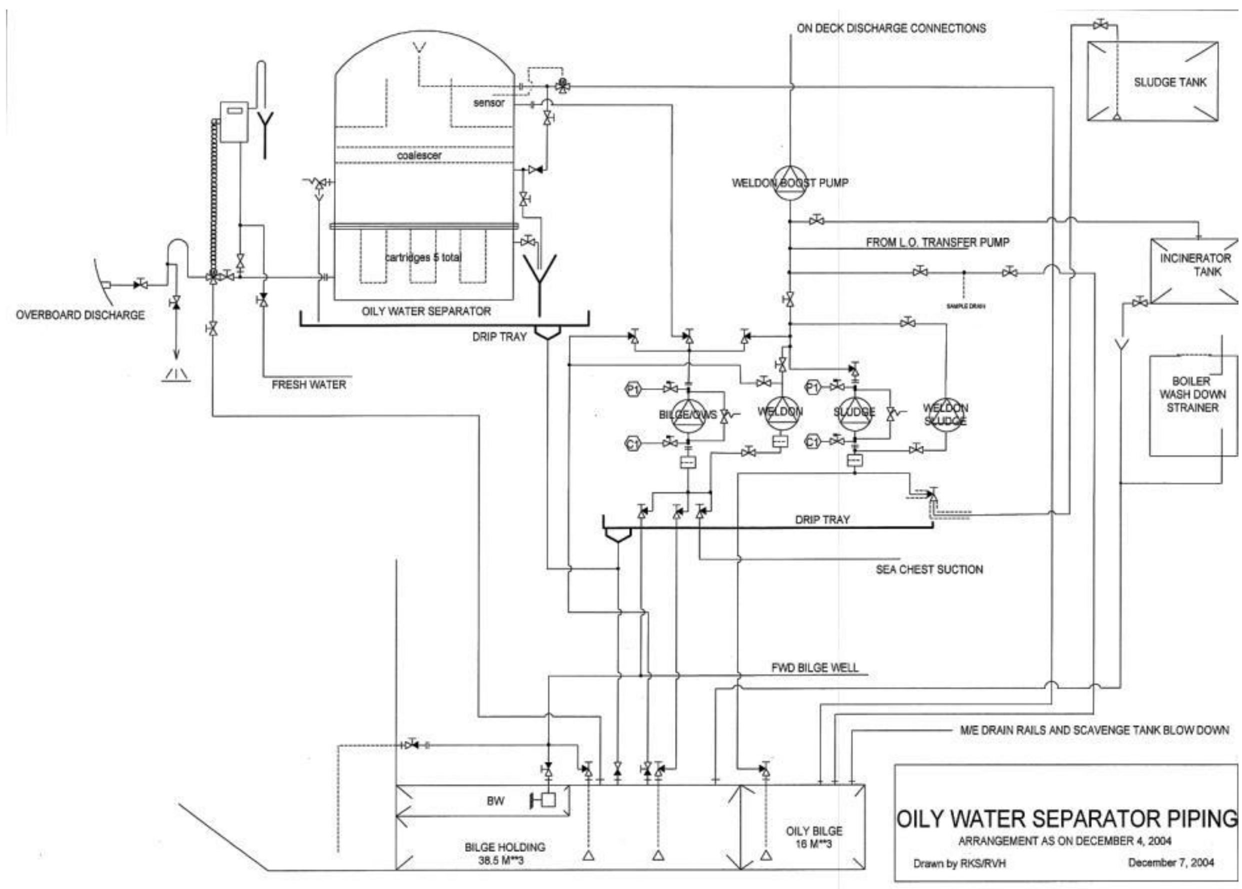
Often the various drains are collected in a bilge holding tank, or a dirty bilge tank. Again there is no standard arrangement for these drains and each ship will present unique problems that require intervention and resolution by the crew to keep the system working.

Undoubtedly such tanks will contain a combination of sludge, water and oil in layers, and the level of each layer and the relative amounts of each product will make a significant difference in how the OWS will respond.

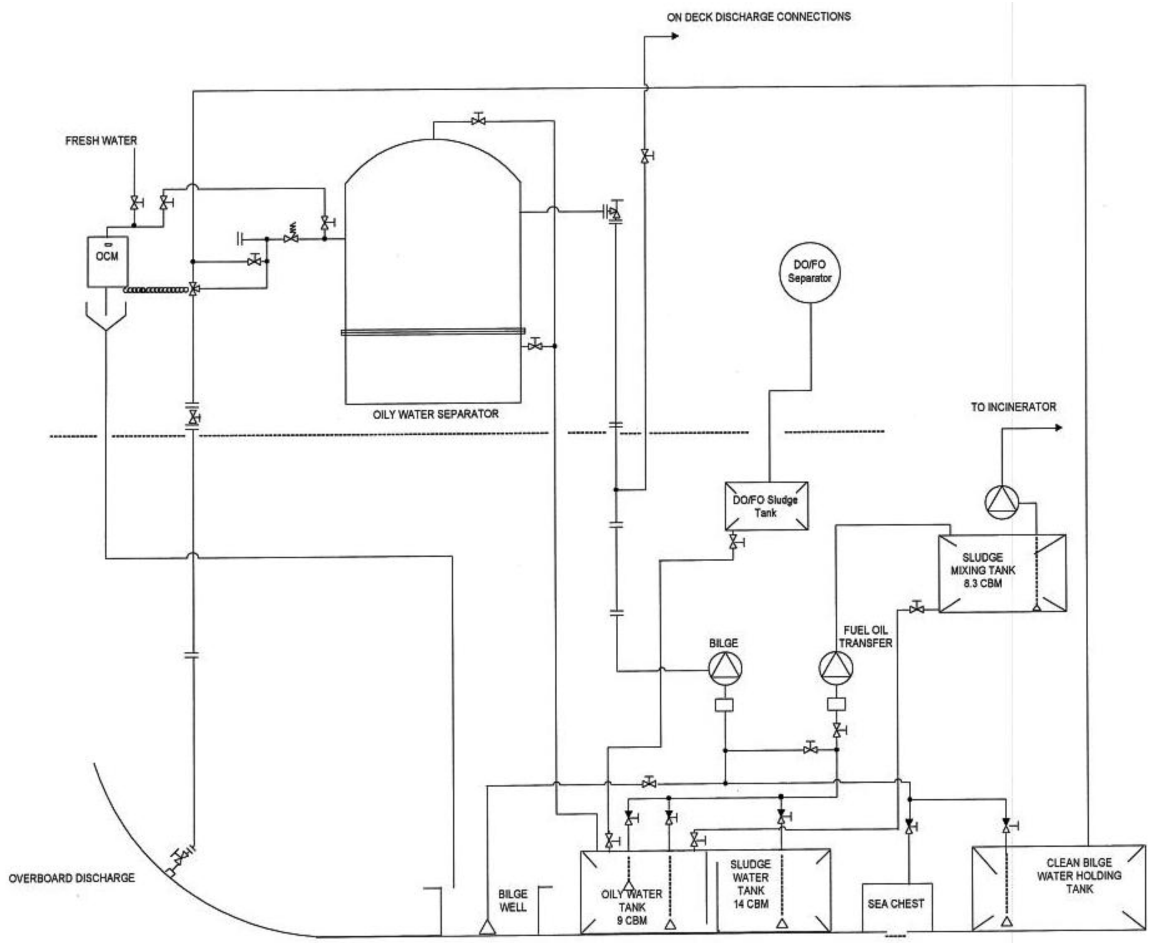
Bilge Water Treatment:

Bilge water treatment takes place when the vessel's crew decides it is necessary to empty the bilges or the dirty bilge water tank.

There are no standard arrangements for the OWS system so on some ships the crews will pump the bilge wells directly to the OWS if they are in an approved discharge area. In other systems the bilge wells are first pumped to a bilge water holding tanks. In some ships the bilge pump can only pump through the OWS, but past the OWS, the treated water can be held in a treated bilge water tank until the bilge water can be pumped over the side, at which time it is again routed through the OWS.



Typical OWS system installation found aboard 1990's built container vessels. Bilge well or bilge holding tank suction system with oil discharge to oily bilge tank. Separate sludge tank. All drains to oily bilge tank including sludge water. Note Boiler wash down strainer drains to oily bilge tank. Boiler soot is a common contaminant that results in OWS failures



Typical system found in 1980's built tankers. Bilge well or bilge water holding tank suction system with discharge to oily water tank. Oily water tank has cascade separation with sludge water tank. Purifier sludge discharges to oily water tank.

Consequently, some crews might run the OWS every day for a short period of time, while other crews might run the OWS once every few weeks. Both systems have advantages and disadvantages and neither is perfect. An OWS performs best when running continuously with a steady mixture flow. Neither arrangement allows this type of operation.

In general terms, OWS operations consist of the following steps:

1. The Chief Engineer decides the OWS should be operated;
2. The level of water in the bilge wells or the bilge holding tank is estimated;
3. The position of the vessel is checked in the wheelhouse to ensure that discharge can take place;
4. The start-up time of the OWS is noted;
5. The OWS is set up for operation and checked. Generally this includes flushing of the OWS with seawater and gradual inclusion of the bilge well line or the bilge tank line flow to the OWS. Often, steam heat needs to be added to the OWS;
6. While the flushing takes place, the OCM is checked to make sure it is working properly, generally the OCM will alarm and the crew spends some time checking the OCM and flushing it with fresh water or cleaning the sample tube;

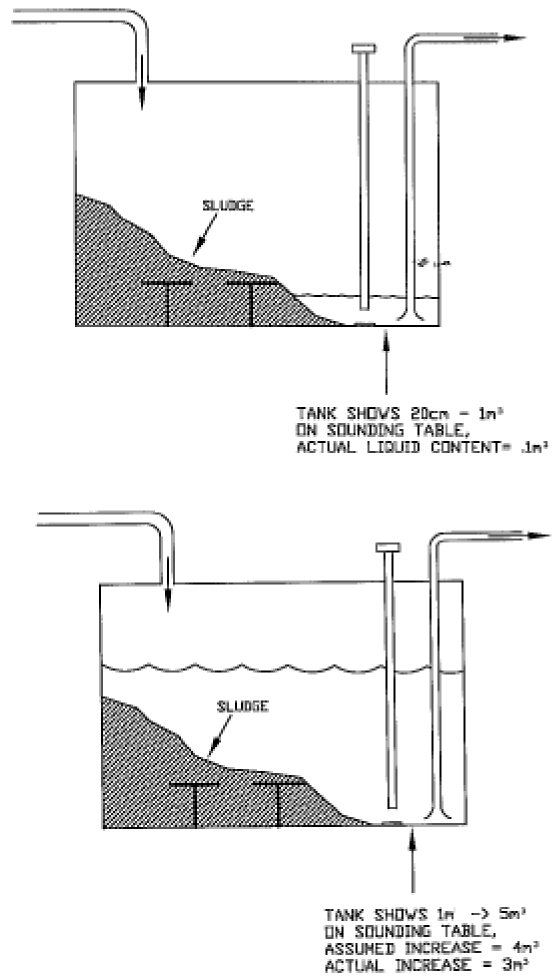
7. Once the OCM shows a low oil content the flow from the bilges is increased
8. At this stage, the operator can go back to other activities as long as the OWS is functioning without problems;
9. As soon as the wells or the tanks are drained, the operator will make some effort to flush lines and flush the OWS;
10. Sometimes the OCM will alarm and the three-way valve will go to the recirculate mode. When the operator realizes the OCM has sounded at the last stages of the discharge, he will flush the lines and the OWS, but not necessarily make an effort to reset the system and flush the discharge line;
11. Once OWS operation is completed, the time is marked and the amount discharged is recorded in the Oil Record Book;

This is a general description of a routine cycle, but any number of problems can occur, and even a normal cycle results in many uncertainties. Generally, the amount of oil separated is not recorded and often this amount is small. Often operators prefer to run bilge water with a high oil content directly to the separated oil tank to prevent unnecessary contamination of the OWS.

While an attempt is generally made to make accurate statements in the ORB, it should be remembered that bilge well volume is not always known and the amount of water in the bilge holding tank also cannot always be accurately estimated. Bilge holding tanks can contain large amounts of sludge that remains in the tank, and will result in over estimation of the amount of water pumped.

Taking into account that the ship's engineers have other tasks than monitoring the OWS, often amounts and times end up being estimated when they are recorded in the ORB hours, or days, later. Sometimes these estimates contradict with the OWS processing capacity and result in accusations of ORB tampering.

Most of all, when reviewing an Oil Record Book, it is assumed the OWS operating cycle was routine, while in practice, every cycle is a little different, and the crew does not bother to record each cycle in great detail.



Example of how sludge can influence the accuracy of tank volume measurements

In order to reduce the amount of slops and dirty oil that needs to be incinerated or taken ashore to an absolute minimum, vessel crews often perform decanting operations that are difficult to describe in the ORB and therefore are not logged. Again, this can result in misinterpretations when reviewing oil record book entries.

In times of an engine room emergency or major maintenance procedure, record keeping tasks often need to be deferred and once record keeping is brought up to date amounts and time have to be estimated.

Waste Oil Storage:

Waste oil is stored in a dirty oil tank. Sometimes this tank is referred to as the slop tank or separated oil tank. This tank might or might not be common with the Fuel Oil Purifier sludge tank. The quantities that go into this tank are not directly monitored, instead the tank levels are taken at a regular interval and recorded in the ORB. Often, ship's engineers double decant this tank to reduce water to an absolute minimum to allow for more trouble free combustion in the incinerator or to reduce the amount of slops sent ashore.

It is important to arrange this tank such that only discharge of slops to an incinerator or to the shore side discharge can be performed. Any arrangement or presence of temporary fittings that could allow discharge from this tank to any other location could be interpreted as a means of illegally discharging oil overboard.

Unfortunately ship operations are such that for any number of reasons it might be reasonable to have additional fittings on this tank. Simple decanting of excess water might be one of those reasons.

Waste Oil Disposal:

Once oily water separation has been successfully accomplished and the separated oil has been stored in a designated tank, the vessel's crew must dispose of the separated oil. This is accomplished either through the incinerator or by discharge to shore. Both systems have their own unique problems.

Incinerators allow a vessel to dispose of oily waste on a continuous basis and thereby can prevent a shipboard crisis if the ship runs out of dirty oil storage space before dirty oil can be discharged to shore. However, incinerators tend to be temperamental and manpower intensive to operate and incinerator equipped vessels generally have less dirty oil storage capacity than ships without incinerators. From a regulatory point of view, incinerators also are a nuisance since an inoperable incinerator can be considered to be a deficiency at a port state control inspection. Also, it should be noted that an incinerator prevents a third party from verifying that dirty oil is properly disposed of, since it literally goes up in smoke while the ship is on the high seas.

At this stage, within the present regulatory environment, operators are cautioned to dispose of dirty oil through an incinerator since any irregularity with the OWS will often lead to the conclusion that oil is not being incinerated, but actually being pumped overboard regardless of what the ORB states. At the same time if an operator decides not to use the incinerator, due to regulatory requirements, the crew is placed in a position where they have to maintain and test an incinerator, but do not get to use it for oil disposal.

The principle of shore disposal is simple. When the dirty oil tanks are close to full, the ship orders a truck or a barge to accept the oil at the next available port. Generally, there is a charge for this service and it puts an additional burden on the crew while the vessel is in port, which today is the busiest time and often precedes or follows periods where crewmembers get little rest. It is noted that "high quality" dirty oil with a low water content is occasionally accepted ashore at no charge since these oils are occasionally recycled.

Central to shore discharge is the need to obtain a shore side disposal receipt. While this panel has not encountered falsified shore side receipts, it would appear that there are plenty of opportunities for fraud in this regard, which prosecutors could use to question the validity of shore side receipts as evidence of proper disposal.

Oil Record Book:

Some Oil Record Book issues have been discussed above. The ORB is used to verify that the vessel's crew is paying proper attention to oil management from an anti pollution point of view.

The ORB has been in use for quite a number of years now and crews have developed various habits in filling it out. Without strict instruction and with different arrangements and operational habits in each ship it is not unusual to discover that a book is being filled out in the right spirit, but in the wrong way.

The book uses a time entry system, but surprisingly does not use an oil quantity book keeping system even if it is supposed to keep track of oil within the ship. Even though it is not a quantitative book keeping system, the USCG often uses the entries to reconstruct the flow of oil on a quantative basis.

The USCG has recently updated the US version of the Oil Record Book (rev. 04-05). This book is a major improvement from the prior version (rev. 7-93) that contained many errors and inconsistencies in the instruction section. For US flag vessels this oil record book can be ordered through the USCG MSO offices. It is recommended that US flag ship owners obtain these books and direct ship's crews to retire the old version books and start using the new version.

Despite many improvements it is noted that the instruction section still raises some questions such as:

- Page 7 provides OWS operation sample entries. It provides a sample entry that shows a failure of the OCM. Close examination indicates that this entry must refer to a failure during a discharge to a collecting tank. This example seems to indicate that an incorrect reading OCM should be logged. Taking into account that a "normal" OWS operational period could have many incorrect alarms does this mean that during a "normal" discharge the crew would have to make numerous entries in the ORB for one OWS discharge cycle?
- The new MEPC 107 (49) OCM will be fitted with alarm recording devices. If the recorded alarms do not conform with the alarms recorded in the ORB will that be an ORB recording violation?
- Page 3 states "The ORB contains many references to oil quantity. The limited accuracy of tank measurement devices, temperature variations and clingage will affect the accuracy of the reading. The entries in the ORB should be considered accordingly". What does this mean? Will the USCG not pay close attention to the quantities when they review the book? Should the crew work very hard at providing consistent readings? Should the crew simply record what they read and hope the USCG will understand there will be inconsistencies?

On a lighter note, the cover of the ORB provides a Paper Work Reduction Act footnote that states that the average burden for this report is 2.5 minutes. It is not clear what constitutes "a report", but even one entry takes more than 2.5 minutes to prepare when the entire manpower/recording chain is included.

In May of 2004 the International Association of Independent Tanker Owners (INTERTANKO) prepared "A Guide for Correct Entries in the Oil Record Book (Part 1 – Machinery Space Operations). (Ref. 22) This guide is an excellent first effort at providing shipboard crews with additional background information on maintaining ORB's. Nevertheless, this guide assumes that OWS systems function reasonably well, and tries to anticipate the interpretation of ORB entries when the ORB is reviewed by a regulatory agency.

As examples the following comments are provided on this guide:

- The guide provides estimates for appropriate amounts of sludge and bilge water for vessels of various tonnages. This information is helpful to the industry at large, but might mislead crews into thinking that if they are recording different amounts they might get into trouble with regulators.
- On Page 3 in the last paragraph the Guide notes that it is not permitted to leave any

full lines empty between each entry. The new USCG ORB actually leaves a blank line between entries in its example section.

- On Page 16 the guide suggests that the oil discharge from the OWS to the sludge tank be recorded in the ORB if the sludge collecting valve has been activated. This would be an interesting and useful bit of information, but unfortunately in practice, with present equipment and with sounding inaccuracies this it is almost impossible to determine. This might result in crews recording this information by reverse analysis, which would not conform with regulatory ORB record keeping practices.

The SNAME Ad Hoc panel is working with the INTERTANKO panel on consolidating information and it is anticipated that this will result in an updated version of the Guide.

Human Factors:

Human factors have been partially addressed under the bilge water section above, but beyond direct human contact with the equipment, there are greater human factor issues that relate to the effectives of OWS systems.

As stated in the background section of this paper, OWS systems are quite dissimilar from traditional ship system. Traditional ship systems exist to enable the ship to carry cargo and to move from port to port. In addition, the vessel is fitted with safety systems that protect the crew of the vessel.

Cargo Carrying (including passenger carrying) systems and propulsion systems are market driven. Since they are market driven, they tend to move to ever-higher efficiencies and provide direct rewards to owners and crews that make improvements to the system. Furthermore, owners and crewmembers are engaged by these systems on a continuous basis.

Ship safety systems are considerably newer than cargo carrying and propulsion systems and are not market driven. Ship safety systems exist for the benefit of the crew and often have been introduced by collective action of crewmembers and at the direction of regulatory agencies. Still a crew is not continually engaged with ship safety systems and it is no secret that it is difficult to have crewmembers pay proper attention to safety systems even though they exist solely for the benefit of the crew.

All the way on the bottom of the motivational pile we find OWS systems and associated systems as systems that exist for the benefit of the public rather than for the benefit of the owners and the crew. Systems such as these are not automatically functional from a human factors point of view. Instead, additional motivational procedures need to be introduced to induce crews to properly operate those systems. It is important to note that this sentence contains two variable concepts. One is “motivational procedures”, while the other is “proper operation” neither have been effectively established and consequently it is unrealistic to expect that OWS systems can be expected to operate properly.

One motivational procedure, the threat of random and severe penalties, is presently being applied. Another motivational procedure that has brought some results is incentives for whistle blowers. However both of these procedures have rather significant drawbacks and further investigation into development of alternative motivational procedures is desperately needed.

It has been suggested that this issue can only be resolved by a direct reward system to the vessel’s crew. This means that the crew should receive a bonus for sludge delivered to shore. However, to date, there have been no suggestions as to how a satisfactory crew reward system can be introduced.

The passenger/cruise industry in their resolution of the OWS system problem has hinted at another possible human factors solution. The most progressive cruise lines now have an environmental officer as a standard member of a ship’s crew. This officer is tasked with taking responsibility for all shipboard functions that have an environmental impact. This provides a vessel with an individual who has an interest in increasing efficiencies, is not distracted by other systems and who has an immediate responsibility in executing his duties in a professional and responsible manner. In effect this officer would be a "public interest" officer

Shipowners might shudder at the idea of having to bring an additional officer aboard, but as long as every ship has to have one of these officers aboard, the playing field stays level and it will not negatively affect an owner's bottom line.

There is a reverse precedent to this type of officer and that is the Radio Officer. Advancing technology has pretty much eliminated this shipboard position, although the effect has not always been positive since often a good radio officer was a very important administrative assistant to the Master. Maybe advancing technology now requires the addition of a new officer position aboard ocean going ships, and maybe IMO should consider this position as a natural outflow of increasing numbers of environmental systems and record keeping requirements aboard ships.

If not today, certainly in the near future there will be more than enough tasks to ensure that "Environmental Officer" is a full time position.

Now let's return to the other variable noted in the statement on human factors a few paragraphs ago: "proper operation." Lack of reliable (as in fire and forget) technologies and systems makes the concept of proper operation unattainable at this stage. Only when "proper operation" can be defined would it be reasonable to hold a person to it, and in this regard there is an urgent need to improve the present state of the art in OWS systems.

It should be remembered that proper training will always improve system performance even if the system is inherently unreliable and unpredictable. In this regard, OWS system training should take a larger part in all shipboard personnel training curricula. At this stage it appears that training should focus on record-keeping skills, OWS maintenance practice, and system operational practices. Unfortunately training cannot be standardized because all systems operate differently. In this regard it could be concluded that there is a real need for greater standardization in OWS system design and operation.

It could be concluded that human factors issues are related to ship's crews alone, but it is important to emphasize that this is not the case in OWS system operation and design. As an example, it is noted that Naval Architectural and Marine Engineering design curriculums completely ignore the existence of systems that serve the public. As such, a graduate Naval Architect or Marine Engineers will not have any education on the design of such systems. This has resulted in generally very poorly designed OWS systems aboard ships. Consequently, training on OWS and associated systems should extend from the designers through the shipyards through the engine room crews.

Finally it should be remembered that "culture," especially peer-influenced culture, in the end, will save the day. A crew or operator that takes pride in environmental responsibility will always do better than those who do not understand. Fortunately this type of pride is spreading and continued attention to this aspect of environmental conservation will always provide positive results.

Regulatory Enforcement Agencies:

There have to be sufficient controls as part of the system that ensure that all ships properly operate the OWS system. At present, the ultimate control rests with the various regulatory enforcement agencies, which in the United States is primarily the United States Coast Guard, although prosecution of violators is run through the various District Attorney's offices.

A properly designed system will make it clear and easy for regulatory enforcement agencies to determine if OWS system regulations are being violated. At present, there is no clear and efficient method of determining whether regulations are violated or not. At the most basic level, it is noted that the absolute absence of any type of standardization of OWS systems makes the initial investigation confusing, dirty, time consuming and sometimes plain incorrect.

Working?

Or not?

It is also noted that in the marine industry there is a long standing and important tradition of "jointness" in marine forensic investigations, where all parties at interest examine the same things at the same time. (See ref 25). However, due to the criminal character of OWS violations the jointness concept is abandoned, which leads to very poor technical investigative methods and severe unnecessary disruptions to vessel operations.

At present the USCG is collecting public comments for the Notice of Proposed Rule Making on the IMO MEPC 107 (49) regulations (See ref 21). This NPRM is available at http://a257.g.akamaitech.net/7/257/2422/01jan20051800/edocket.access.gpo.gov/2005/pdf/05-21573.pdf It is recommended that owners, operators, manufacturers and crews review these rules and provide the USCG with their comments. Comments are due by February 1, 2006. See http://www.uscg.mil/hq/g-m/regs/2005.html for further details on submitting comments.

Waste Oil Receivers:

As described above, the waste oil receivers are an important factor in the OWS system. It appears that at present the ability to discharge small amounts (25 tons or less) of slops has improved. Nevertheless often the ordering of waste receivers in ports is left to shore personnel who do not necessarily feel the same level of urgency about discharging slops as shipboard personnel.

If there were a worldwide approved database of waste oil receivers, shipboard personnel could order a receiver directly and know they are not at the mercy of the Monday to Friday and company holiday schedule of shore side personnel. It is noted that at present there is an effort to create such a database through IMO MEPC 53 (Search IMO for Port Reception Facility Database (PRFD) and IMO Global Integrated Shipping Information System (GISIS)).

At present owners or charterers pay for waste oil disposal, unless there is a receiver who will accept low water content waste oil for re-refining. Payment by alternate methods (for example by including unlimited waste oil disposal in port charges) might improve the motivational pattern for waste oil disposal. In Europe there are now ports that will receive waste oil at no charge, but to date there has been no public review to determine if "no-charge" discharge is subject to resultant abuse such as dumping of non-oil waste, or dumping of excess water instead of mostly oil.

From a pure systems point of view, it could be argued that if there are sufficient shore receiving facilities and if ships are fitted with sufficiently large holding tanks there would be no need for ship based OWS systems. A detail analysis might show that the cost to the public of a system like this would be much lower, and it would certainly reduce the stress on shipboard crews.

Economic Factors:

Every system contains economical factors. To date the economics of OWS systems have not been analyzed. At best, shipowners analyze the acquisition costs of OWS equipment, and possibly the operational costs of the equipment.

A rational approach to OWS design would require top to bottom life cycle cost analysis of all OWS systems and approaches to determine the actual cost to the public, regulatory agencies and to ship owners.

There are tantalizing indications in the industrial community at large, and to some extent in the maritime community that efficient environmental and pollution reduction program are a net benefit to corporations and can actually reduce overall operating costs.

PRESENT EFFORTS AT IMPROVING THE STATE OF THE ART

The above portion of this paper describes the problems associated with OWS systems. To a large extent the problems with OWS systems have been known for many years. Nevertheless, there never has been a truly technical approach to the problem, and to a large extent all attempts at resolving problems have been regulatory, political and judicial.

In order to develop technical solutions to the OWS system problems, the Society of Naval Architect and Marine Engineers has formed a research panel under their Technology and Research group. This panel, named SNAME T&R Ad Hoc panel 14, Oily Water Separators, intends to develop technical OWS system solutions that will lead to higher efficiency and effectiveness of OWS systems.

(http://www.sname.org/technical_committees/adhoc/ leads to the SNAME Ad Hoc 14 website)

SNAME has prior experience with Ad Hoc panel activities although this effort is probably the largest effort to date. SNAME actively and eagerly is soliciting input from all interested parties in OWS system design and will make every effort to provide a neutral forum that will result in solutions that benefit the public and the operators alike.

The SNAME Ad Hoc panel is interacting with other panel such as the ASTM panel on OWS and the INTERTANKO panel on OWS operational guidelines to reduce duplication and to increase uniformity.

In order to stimulate debate, this paper is making a number of recommendations with regard to OWS system design and operation. This set of recommendations will be referred to as SNAME Ad Hoc 14 Mark1 and is by no means considered to be complete or final.

It is hoped that these recommendations will result in a vigorous debate, which in turn will result in more complete and technically optimized subsequent versions.

At this stage, these recommendations will address the following system aspects:

- System terminology
- System design
- System operational and training manuals
- System equipment manuals
- Oil Record Book recording methods
- Training

- System inspection

Additional areas of investigation are outlined in Reference 17, but will not be addressed in this paper.

SYSTEM TERMINOLOGY

When performing OWS system inspections it becomes shockingly clear that there is very little consensus on OWS system component terminology. The wide variety of terminology results in confusion at the training, inspection, and operational level. For example an OCM is defined as the Oil Content Monitor. However, many official documents do not use this term, but rather the term Bilge Monitor. The term Bilge Monitor is not readily identified as a component of an OWS system but sometimes is thought to be the bilge level alarm, which performs a function that is entirely unrelated to the OWS system.

Although presently well established, the term "OWS" is also a misnomer since the device needs to handle other substances besides oil and water and needs to be specifically designed for bilge water rather than an abstract mixture of oil and water. The ASTM F 2283 – 04 panel has elected to use the term Shipboard Oil Pollution Abatement System, but this term probably also fails to fully and clearly describe the system discussed in this paper. A more appropriate term is probably something like Bilge Water Discharge Treatment System.

This mix in terminologies makes it difficult to perform internet searches on technology. For example an OWS and ASTM search will not provide a link to the ASTM standard for OWS systems.

The panel has made a survey of OWS system related documents and made a terminology list with associated definitions.

For reference, the list of identified terms is available on the Ad Hoc website and additional terminology submissions are requested. Review of this list by panel members has resulted in a consolidated list of recommended terms and definitions that is also provided on the website.

It is recommended that the terms in the consolidated lists be adopted by the industry and regulators, and most of all in training manual, equipment manufacturers manuals and shipboard documents and drawings.

SYSTEM DESIGN

At present no clear guidance on the systematic design of OWS systems is available.

Nevertheless besides the Ad Hoc panel 14 activities some encouraging trends appear to be developing.

Recently ASTM published its first Standard Specification for Shipboard Oil Pollution Abatement Systems (Standard F 2283-04, ref 19). This standard provides a wealth of information that equipment purchasers can use as a specification basis for purchasing OWS equipment.

While it is a huge step forward in a standardized approach to OWS equipment procurement, its scope does not include the actual system design and evaluation aboard ships. Also this standard is still an early effort that will require further industry evaluation to make it sufficiently rugged for general acceptance.

Evaluation of overall systems is the type of function that for many ship systems is covered in classification rules. Surprisingly classification societies do not provide any rules or guidance on OWS systems and, as such, there is no trend towards improvement or standardization of such systems aboard ships. Recently classification societies have started to promote their involvement in Human Factors (see ref 26), but it is almost ironic to note that, to date, classification societies have not recognized the human factors problems associated with OWS systems and other "for the public" shipboard systems.

It is recommended that in future classification rule updates the classification societies will respond to their professed mission of serving the public interest and will start to include at least some basic system design guidance for OWS systems.

Such guidance could focus on issues such as:

- Equipment installation for maintenance. It is not at all unusual to see equipment installations that require removal of the entire unit to replace a pump impeller.
- Proper pipe sizing. Often OWS oil discharge lines are too long and too small in diameter to effectively transport viscous waste oil to waste oil tanks
- Proper pump sizing and performance. Most sludge pumps used for discharging sludge to the deck line are too small and weak to effectively discharge waste oil in the short period that is generally allotted while a vessel is in port
- Proper waste and bilge water tank design.
- Alarm and sensor design that truly benefits operating crews
- System standardization
- Proper operational testing systems

A System Design Example:

To illustrate the effects of greater attention to system design, it was found during discussions with operating personnel, that availability of decanting tanks within the vessel greatly alleviates problems with OWS operation. (Ref 13, also indicates the desirability of decanting tanks) This led to further discussions regarding OWS system design that indicated that holding tank design should become a more prominent component of the OWS system. At present the vast majority of bilge water treatment tanks are double bottom tanks. Double bottom tanks tend to be long and flat, which results in poor initial gravity separation, difficult sludge removal and tank cleaning, poor measurement accuracies and excessive sloshing.

To further discuss the higher integration of decanting tanks a sample OWS system diagram that incorporated such tanks was prepared. This diagram is shown below.

An OWS system such as this makes higher demands on engine room configuration design than for the OWS systems that are presently found aboard ships.

The big benefit of this system is that it allow crews to manage and handle the varying oil/bilge water supply rates and provides them with reasonable assurance that the OWS can do what it is designed to do and will not be subjected to severe levels of oil content or sludge content that tend to result in OWS malfunction and operational/maintenance problems.

The inability to manage and handle the varying rates and ratios of oil and water before they enter the OWS appears to be the single most important factor in shipboard OWS malfunctions and this system specifically provides ship's crews with components to address this problem.

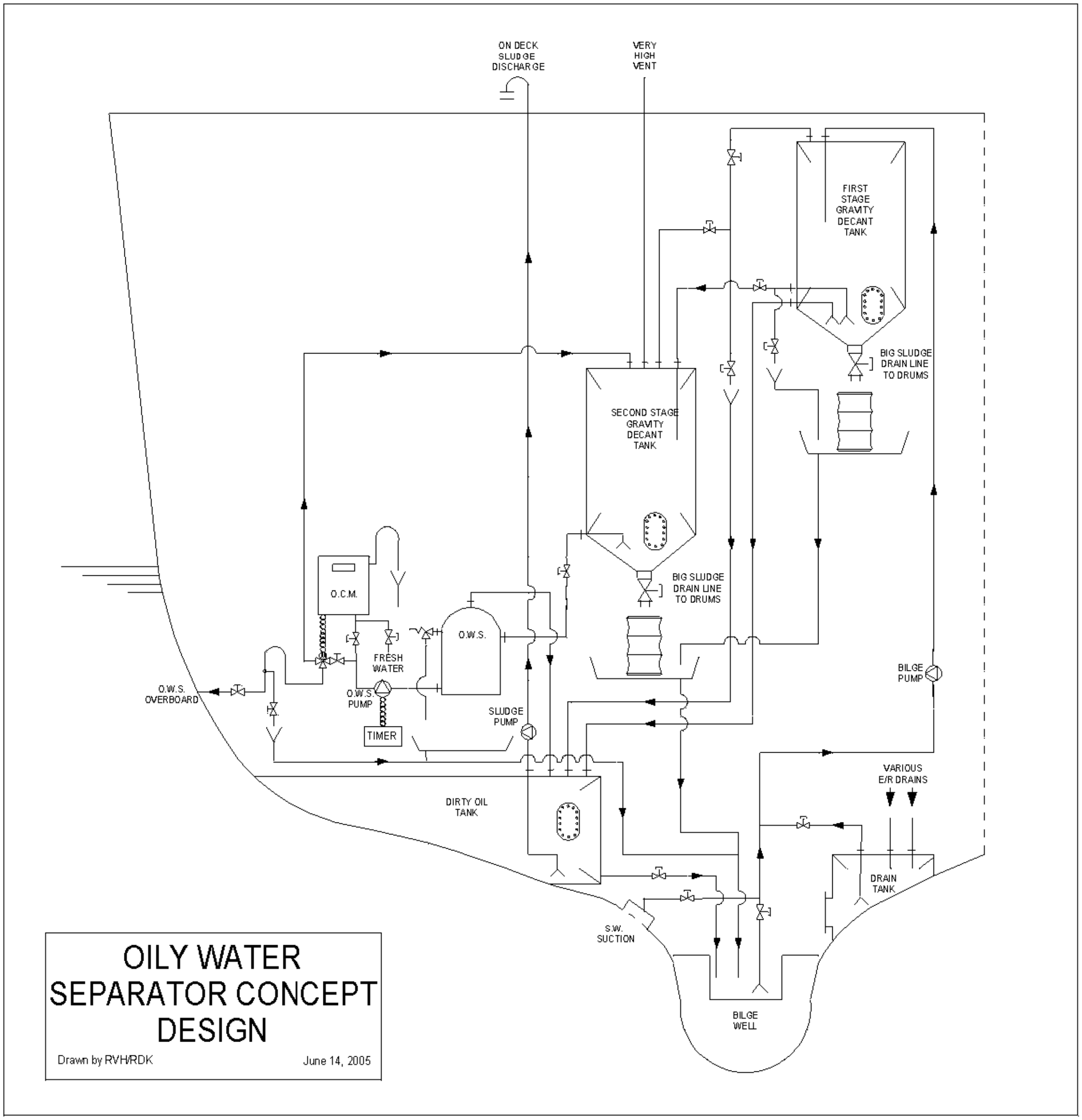
This tank arrangement also could be conducive to in-tank skimmer arrangements such as have been proposed by operating engineers (NCL operating staff, as reported by K. Olsen of the USCG.)

As with all design, God is in the details.

As such, issues such as actual arrangement of the system within the engine room are of great importance.

This particular system has a distinct vertical aspect and its benefits will decrease if the decanting tanks are not sufficiently vertical and if gravity cannot perform the bulk of all the operations.

The system, as drawn, does not rely on automations, and will require hands-on operation by an engine room crewmember. There is no indication that the actual crew workload will be any lower with this system, but since the system is divided into separate steps, crews will have greater flexibility in scheduling tasks. Once the OWS is running there is a much



Sample OWS System design incorporating vertical tanks

greater chance of uninterrupted OWS operation, which will benefit ORB recording procedures and regulatory inspector confidence.

This system could be automated to a significant extent, but then would rely heavily on sensors. Any sensor that comes into contact with oil is subject to fouling and therefore increases sensor maintenance.

Nevertheless any method for reliably sensing oil and water levels in the decanting tanks would be of great benefit and research and suggestions in this regard are very much welcomed.

In this regard a small Ad Hoc 14 project that is evaluating the effectiveness of viewing windows and clear piping in OWS systems is presently underway. This project is evaluating various materials, coatings and cleaning methods of clear materials that can provide a vessel's crew with a window into their OWS systems. (contact jake@vanhemmen.org for further details)

This particular example uses a "conventional" OWS. However, novel approaches should never be discounted. One example of an out-of-the box approach is bilge water vaporization by means of exhaust gas energy as suggested by Mr. Berrett in reference 13, many other methods centrifugal separation and biological remediation continue to be tried, are being considered and deserve to be further evaluated.

SYSTEM OPERATIONAL MANUALS (ISM)

At present there absolutely are no useable operating manuals for OWS systems. On many ships there are a few paragraphs that refer to OWS systems in the ISM manual.

Those instructions generally contains platitudes such as:

When sufficient liquid has collected in the bilge wells the designated engineering officer is to start the Oily Water Separator and discharge clean water through the approved and calibrated OCM overboard. Oil waste separated in the OWS is to be collected in the designated tank and delivered ashore for disposal. ORB entries are to be made according to the Flag Authority ORB instructions

However, OWS system management is fraught with uncertainties and therefore such instructions are next to useless to a vessel crew.

Since OWS system operation is difficult and since crew training levels on OWS systems are low, ship operators should make an effort to provide onboard guidance that has a higher level of specificity than found in other ISM operations where it can be fairly concluded that crews can make their own decisions.

Most of all, operational manuals should provide guidance on failure logging of OWS systems and guidance on obtaining system improvements. Contrary to propulsion systems, OWS systems are incredibly immature and shipboard feedback is desperately needed to improve those systems.

ISM systems are designed to provide this type of input, and only minor modifications and guidance in ISM system methodology and instructions can provide a wealth of feed back information to ship owners and the design community at large.

ISM Non-conformance reports that provide details such as:

- Today the oil/water interface sensor did not sense oil. The oil sensor operates when tested in clean oil. Is it possible the oil's conductivity is too high? A sample of the oil found in the OWS was taken and will be left ashore for transmittal to the manufacturer
- It appears that any amount of soot in the bilges keeps the OWS from working
- The sewage tank overflow line drains into the bilge tank. Can this drain be rerouted, since biological waste will not process through this OWS?
- The OWS was recently overhauled, but now will not separate the liquid in the bilge tank.
- Cleaner XYZ does not work with OWS ABC

Are of immeasurable help in advancing the state of the art. Owners might not want to see this evidence of OWS failures in their records, but vigorous ISM system communications between crew and owners/operators are actually strong proof of an owner's commitment to proper OWS system operation and design.

SYSTEM EQUIPMENT MANUALS

The vast majority of OWS equipment manuals are of atrocious quality. Ad Hoc panel 14 is requesting that OWS manufacturers who believe that their manuals provide satisfactory guidance to shipboard crews forward copies of their manuals to the panel.

Ad Hoc panel 14 will specifically commend those manufacturers who provide useful manuals and will acknowledge them as industry leaders who have shown a commitment to providing Owners, operators and ship's crews with equipment that will allow them to meet the present requirements.

It is hoped that such progressive equipment suppliers will allow the use of the general design and index of those manuals as guidance in developing a recommended OWS manual format.

At present statutory approval of OWS equipment, or the ASTM standard does not have any specific equipment manual requirements.

TRAINING

Since OWS system design and operation has proven to be difficult and non-conducive to automation, high levels of crew training will therefore be required for successful OWS system operation and design.

At present training levels of designers and operators are non-existent and design staff and operating staff system knowledge is almost non-existent and often wrong. The industry should pay greater attention to the training on these issues at the very basic levels, such as in training academies and engineering schools.

Specifically the following recommendations are made:

- Maritime academies should pay greater attention to OWS system operational training
- OWS system operational training cannot take place without simulators and teaching systems
- Since shipboard OWS training is much more difficult to perform than shipboard propulsion plant training there should at least be a few shore based locations where students can operate, maintain and overhaul OWS equipment.
- Naval Architectural and Marine Engineering schools need to take a close look at their curriculums and decide how they will incorporate design training on "For the public" systems.
- The standard excuse of "We do not have enough time to teach the things we need to teach in the present curriculum" is not an adequate answer and makes a mockery of the engineering profession, which is supposed to solve problems not ignore them.

Besides the grand schemes there are opportunities for improvements in training in the trenches too. The level and quality of labeling of equipment in the OWS systems is generally poor. It is not uncommon to deal with shipboard crews who first need to trace the majority of lines when the OWS is not functioning properly. A proper survey and proper labeling of OWS system components will greatly improve a crew's awareness and knowledge of the OWS system.

As such Ad Hoc 14 is looking for partners such as operating crew unions, manufacturers or seamen's churches who are interested in printing and distributing OWS system information kits that can be provided to shipboard crews as a training aid.

Such kits will include terminology definitions, basic information and labeling and warning sticker packs that can be used in properly identifying system components.

SYSTEM INSPECTION

Use of consistent and clear labeling will improve the level of confidence of regulatory inspections and will allow inspectors to separate the operators that are making a sincere proactive effort from those who are reacting only when the regulatory inspectors start to pay attention.

One specific idea with regard to inspection that has arisen from the Ad Hoc panel 14 efforts was suggested by LCDR Blume of the USCG. OCM's are supposed to be calibrated and tested on a regular basis. In theory an OCM is tested with a calibration liquid, but in practice this cannot be performed reliably onboard a vessel. Instead an OCM is tested by checking if the meter goes to zero when it is flushed with water, and checking if it alarms when the sensor is blocked.

There are many ways to block the sensor such as putting coffee or milk in the sensor tube (tea does not always set off the sensor alarm) or simply sticking a pen or other object into the sensor tube. This test merely indicates that if the sensor is blocked that it will alarm, but does not indicate if the sensor responds at 15 ppm or 1000 ppm.

Commander Blume suggested that it would be helpful if there were a solid object that could be inserted into the sensor tube that has a refractory index or opacity that is equivalent to 15 ppm oil. Fiber optic, polymer coated, and acid etched substrates are currently being evaluated in this regard.

Further thought on this matter has suggested that the device would look like a solid object slightly smaller in diameter than the standard sensor tube size, that has an equivalent opacity of 16 ppm on one end and, say, 30 ppm on the other end.

Such a testing device would be a simple indication that the OCM is at least in reasonable calibration.

If the OCM alarms with the 16 ppm end, the unit is properly calibrated, if the OCM only alarms at the 30 ppm end, it should be considered to be operational, but the unit should be immediately recalibrated.

CONCLUSION

OWS system and equipment design and operation is a difficult, wide ranging and confusing subject. This paper reviews the state of the art and makes a number of recommendations intended to make OWS systems more efficient and effective in the shipboard environment.

There is no doubt the subject is controversial and often deals with contrasting views and interests. The aim of this paper is to increase discussion, and to identify promising areas for agreement and improvement. The panel strives to be accurate, public, efficient, balanced and innovative and welcomes all and any comments that will result in improvements of the state of the art.

All parties at interest are urged to contact the authors at rhemmen@martinottaway.org with their contribution and suggestions.

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Those who go to sea in ships. Shipping is tough and dangerous and those who sail the ships are not getting the credit for their hard work. As an industry, and as the engineers within that industry, it is our duty to ensure that those who sail do not become the victims of our neglect. With regard to OWS system we have failed in that duty and we need to do better.

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