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A Study on the Prevention of Spill of Fuel Oils and Lubricating Oils for Sunken Ships

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Abstract : *A sunken ship often involves an oil spill. This paper was carried out to minimize environmental and cost damages stemming from oil spil of sunken shipl. Through the analysis of both the standards of the oil tank system and installation, we have identified potential oil spill sites and proposed a remedy of prevention. The result of study, the air pipes of the oil tank are a vulnerable point for oil spill. Also, the remote control devices of emergency shut-off valve have poor accessibility at abandon ship, making it difficult to shut off the emergency shut-off valve. Thus, we propose the addition of a remote quick closing valve in the air pipe and the building of a central control system.*

Key Words : *Sunken ship, Engine room, Marine oil, Marine pollution, Air pipe, Remote quick closing valve*

1. Introduction

With the increase of port traffic, mega ships have also increased to address ship energy efficiency. Larger vessels not only carry fuel oils and lubricating oils for engine, but the size of the engine for ship propulsion. In case of a large ship, the fuel oil capacity is over 10,000 ㎘. Its total capacity for oils such as fuel oils and lubricating oils is over 12,000 ㎘. It is no wonder that general cargo ships, other than oil tankers, are prone to similar scale accidents, such as what happened to M/T HEBEI SPRIT accident where 12,547 ㎘ of oil spilled (Yun, 2008; ITOPF, 2015). Also, marine pollution accident that leads to the destruction of marine ecosystems cannot be resolved in a short period with the enormous cost it entails regardless of the type of ship (Yun, 2013). According to the study on the analysis of the total treatment cost of oil spills depending on the cause of the accident, the highest costs are attributed to grounding and sinking. The greatest total costs are observed in cases of sinking because not only may a sinking ship release all of the oil that it carries as cargo or bunker fuel, but the oil leaking continuously for a long period of time requires long-term responses (Ventikos and Sotiropoulos, 2014).

Also, the scale of oil spills domestically is about 850㎘. Oil spills from oil tankers are about 11 ㎘, while general cargo ships are about 528 ㎘ (Ministry of Public Safety and Security, 2009~2013; Kim, 2013a; Kim, 2013b). In case of general cargo ship besides oil tankers, oil spills can come from oils for engine. There are no statistics available about the capacity of oil spills of sunken ships resulting from an accident.

This study centers on cases involving the sinking of ships that load fuel oils and lubricating oils for engine to prevent oil spills. The equipment regulations on the oil tank system and piping in the engine room were analyzed according to the regulated international convention and classification rules and the possible oil spill sites were identified. Also, this study proposed the improvement of regulations, and studied the methods to minimize oil spills.

2. The Regulations of Oil Tank

2.1 Oil Tank

According to the International Convention for the Safety of Life at Sea (SOLAS) 1999/2000 Amend Chapter Ⅱ-2 Reg. 4.2 Arrangements for Oil Fuel, Lubrication Oil, and Other Flammable Oils, as far as practicable, oil fuel tanks shall be part of the ship's structure and shall be located outside machinery spaces of category A. Oil fuel tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A (Machinery spaces of category A are those

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spaces and trunks to such spaces which contain either: internal combustion machinery used for main propulsion; internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 ㎾; or internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 ㎾) or at least one of their vertical sides shall be contiguous to the machinery space boundaries, and shall preferably have a common boundary with the double bottom tanks, while the area of the tank boundary common with the machinery spaces shall be kept to a minimum.

Also, according to the International Convention for the Prevention of Marine Pollution from Ships (MARPOL) 2006 Amend Annex Ⅰ Reg. 12A Oil Fuel Tank Protection, the double bottom shall apply to all ships with an aggregate oil fuel capacity of 600 ㎥ and above which are delivered on or after August 1, 2010 to minimize the damage of oil spills at grounding or collision.

2.2 Air Vent System of Oil Tank

According to the International Convention for the Safety of Life at Sea (SOLAS) 1999/2000 Amend Chapter Ⅱ-2 Reg. 4.2 Arrangements for Oil Fuel, Lubrication Oil, and Other Flammable Oils, prevention of overpressure provisions shall be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes served by pumps on board.

According to the International Convention on Load Lines (ICLL) 2003 Amend ANNEX Ⅰ Reg. 20 Air Pipes: 1) Where air pipes to ballast and other tanks extend above the freeboard or superstructure decks, the exposed parts of the pipes shall be of substantial construction; the height from the deck to the point where water may have access below shall be at least 760 mm on the freeboard deck and 450 mm on the superstructure deck. 2) Where these heights may interfere with the working of the ship, a lower height may be approved, provided that the Administration is satisfied that the closing arrangements and other circumstances to justify a lower height. 3) Air pipes shall be provided with automatic closing devices.

Fig. 1 is a schematic diagram of an air vent head that is built to float. The head has a float and a seat that could open and close for internal pressure, as shown in Fig. 1. It has a structure where air from the internal part can be discharged automatically, but others including rain and sea water from the external part cannot be introduced.

The air vent system shall be with as shown in Fig. 1. However, the air pipes in the whether deck only has air vent head with self-closing devices. The air pipes in other areas are just goose-neck type without self-closing devices. Fig. 2 shows the air pipe of the goose-neck type in a currently sailing ship.

Also, the air vent system shall be the structure which prevents direct inflows of rain or sea water in each tank if the pipe is damaged. Fig. 3 shows the air vent system (piping) of oil tanks for engine. (a) shows that by giving a slope to the main pipe connected to the air pipe from the tank with goose-neck, the rainwater inflow leads to a bilge tank. (b) shows that it has a manifold of air pipes for oil tanks and the rainwater leads to a drain tank through the drain pot in the manifold. (c) shows that the rainwater in the manifold leads to the bilge well with self-closing valve. (d) shows that it has an angle to the air pipe

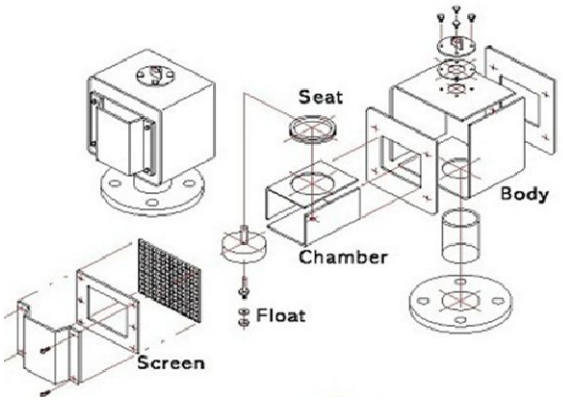

Fig. 1. The Structure of Air Vent Head.

Fig. 2. The Goose-neck type of Air Vent Head.

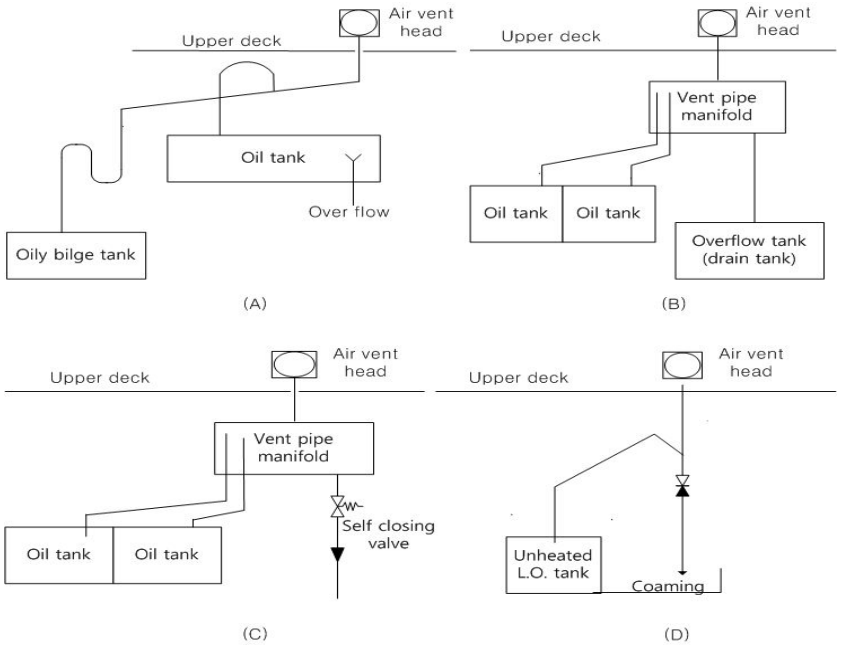

Fig. 3. The Air Venting System (Piping).

of oil tanks for prevention of inflow while the rainwater inflow leads directly to the tank's coaming (Korea Register, 2015; Ministry of oceans and fisheries, 2015). Thus, the air vent system of oil tanks cannot introduce the rainwater and the seawater due to the structure that does not direct inflows of rain or sea water in oil tanks, lead to a bilge tank or drain tank if the pipe is damaged.

2.3 Quick Closing Valve

According to the International Convention for the Safety of Life at Sea (SOLAS) 1999/2000 Amend Chapter Ⅱ-2 Reg. 4.2 Arrangements for Oil Fuel, Lubrication Oil, and Other Flammable Oils, oil fuel pipes, which, if damaged, would allow oil to escape from a storage, settling, or daily service tank having a capacity of 500㎘ and above situated above the double bottom, and shall be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space concerned in the event of a fire occurring in the space in which such tanks are situated. The controls for remote operation of the valve for the emergency generator fuel tank shall be placed in a separate location from the controls for remote operation of other valves for tanks located in machinery spaces. Fig. 4 is a schematic diagram of the emergency shut-off valve available for remote control. Generally, this valve operates in pneumatic control and can be closed by remote.

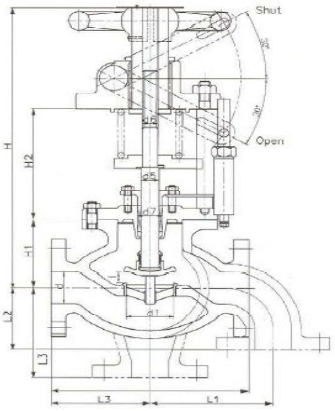

Fig. 4. Emergency shut-off valve (Quick closing valve).

2.4 Sounding Pipe

According to the International Convention for the Safety of Life at Sea (SOLAS) 1999/2000 Amend Chapter Ⅱ-2 Reg. 4.2 Arrangements for Oil Fuel, Lubrication Oil, and Other Flammable Oils, where sounding pipes are used, they shall not terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they shall not terminate in passenger or crew spaces. As a general rule, they shall not terminate in machinery spaces. However, where the Administration considers that these latter requirements are impracticable, it may permit termination of sounding pipes in

machinery spaces on condition that all of the following requirements are met: an oil-level gauge is provided meeting the requirements of oil-level gauge regulation; the sounding pipes terminate in locations remote from ignition hazards; and the termination of sounding pipes are fitted with self-closing blanking devices and with a small-diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that oil fuel is not present. Provisions shall be made so as to ensure that any spillage of oil fuel through the control cock involves no ignition hazard. The sounding pipe is always blocked due to the role of the self-closing control cock and self-closing blanking devices.

3. The Oil Spill Possible Sites

3.1 Oil Tank

All ships with an aggregate oil fuel capacity of 600 ㎥ and above, which are delivered on or after August 1, 2010, should meet the double bottom regulation. Double bottom tanks have to reduce the possibility of oil spill from grounding or sinking. It is better than single bottom tanks.

3.2 Air Vent System for Oil Tanks

Prevention of overpressure provisions shall be made to avoid overpressure in any oil tanks of ship. In accordance with the related regulation, the size of air pipes is conditioned by the size of tanks; the air pipes would be checked for self-closing devices according to the location; and they have been installed above the freeboard deck without the hazard of fire. There are two types of float on self-closing device in the air pipe head: plate type as shown in Fig. 1 and ball type. In the event the water filled in the outer part of the air pipe head, an inflow of rain and sea water is prevented by the float role. However, in case of sinking or a slant of grounding, the float cannot shut out oil spills in tanks. The head of goose-neck type as shown in Fig. 2 cannot stop oil spills. Also, as seen Fig. 3, there are no shut off devices of pipes from oil tank to freeboard deck. The results were analyzed and this point has the highest potential of oil spill from sinking or slant.

3.3 Sounding Pipe

The sounding pipe is always blocked due to the role of self-closing control cock and self-closing blanking devices. However, in the event the sounding pipes terminate in location outside the engine room, the self-closing device is not required. Generally, it is exposed to single-closing by a screw cap. Thus, there is a potential of oil spills by sounding pipes, in case of damaged sounding pipe or lost cap.

4. Results and Improvement Consideration

4.1 Air Vent System for Oil Tanks

According to a 2004 report, it has been reported that when the air pipes were closed by temporary expedient at the moment of overturn as a warning for sinking, there were no oil spills (KCG and KMPRC, 2004). It indicated that oils spilled through air pipes if not damaged. At current regulations, if sinking occurs, air pipes are closed by underwater divers or during salvage because air pipes for oil tanks have no shut-off valve. Thus, this study suggests that in air pipes for oil tanks, emergency shut-off valve is installed. Because the air pipes of oil tank are always opened to prevent overpressure, through regular check and maintenance, they are maintained usually open and operated smoothly. It is possible that to prevent oil spills in the event of sinking and grounding, the emergency shut off valves should be closed.

Fig. 5 shows the air vent system of the oil tank that adds emergency shut-off valve in air pipes.

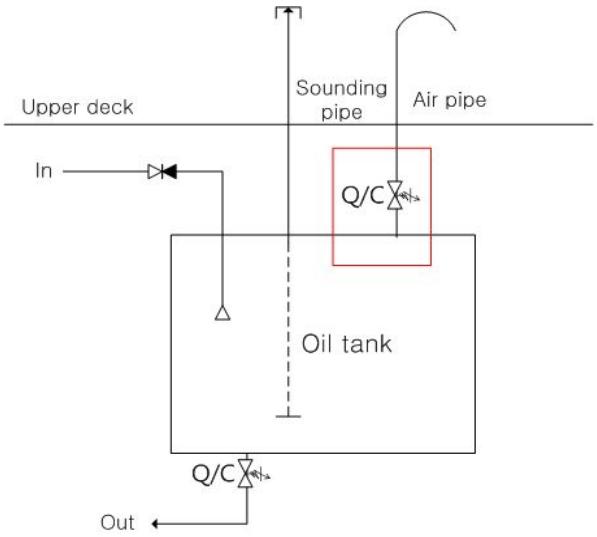

Fig. 5. The Arrangement of Emergency shut-off valve (Quick closing valve).

4.2 Sounding Pipe

We suggest that sounding pipes installed in the area outside the engine room be fitted with a self-closing control cock and self-closing blanking devices. At current regulation, because sounding pipes are of single structure fitted with screw cap, double structure devices for damaged or lost cap are necessary.

4.3 Central Control System of Emergency Devices

The remote control devices of the emergency shut off valve in the outlet pipe of oil tanks shall be in a separate location from the engine room. Generally, they are fitted in the entrance of the engine room or the fire control room of the upper deck. However, this has poor accessibility at abandon ship, making it difficult to shut off the emergency shut-off valve. Also the objective of the emergency shut-off valve in the outlet pipe of oil tanks is to prevent fire fighting in the engine room and to immediately stop the engine in abandon ship. In ship drills and ship education, the situation of sinking is often not included. This study suggests that the location of remote control devices be accessible in case of emergency and that the central control system of the remote control device on the watertight door, the fire damper, and all emergency shut-off valve be installed.

In an international convention, the muster list shall show the duties assigned to the different members of the crew closing watertight doors, fire doors, valves, scuppers, overboard shoots, side scuttles, skylights, portholes, and other similar openings in the vessel (SOLAS 1996-1998 Amend / Chapter Ⅲ / Reg. 37). In the event of emergency like sinking, however, it is difficult to access remote control devices without a central control system in possible access areas. Thus, a central control system for all emergency shut-off systems including the emergency shut-off valve suggested above in air pipes must be installed. Also, its location shall be in the muster station and bridge.

4.4 Emergency instruction

In international convention, the main contents about the drills are the type of training, period, and basic information (only fire fighting/abandon ship). The details, such as the duties of the sailor are established by the ship operator. In most emergency instructions, the emergency shut-off valve should be closed during fire in the engine room. Also, without an emergency response procedure of oil spills, other response procedures do not include the action to minimize the marine pollution from ship.

We suggest that action about the emergency shut-off valve in emergency instruction be added. By including instructions on operating the central control system of the emergency shut-off valve, it is possible that it is checked for smooth operation and sailors would become familiar with the procedure. If the first responders should cope and assume the worst such as abandon ship or sinking in the emergency situation of ship, oil spills from sunken ship will be minimized because the action is taken at the first responders. Further, the sailors can concentrate on abandon ship with a more rapid and safe escape.

5. Conclusions

Fuel oils and lubrication oils are loaded in ships regardless of the type of vessel. With larger vessels, the loading capacity of oils has increased significantly. General cargo ships other than oil tankers have the potential to create large oil spills. This study was carried out to avoid spills of oils such as loaded fuel and lubrication oils in all ships aside from cargo oils of oil tankers. By preventing oil spills after sinking or grounding, we can minimize marine pollution. As a result of this study, in the event of sinking, to avoid oil spills including fuel oils and lubrication oils for engine, this paper suggests that:

First, in the air vent system of all oil tanks, air pipes shall have an emergency shut-off valve including remote control devices. Further, it has to be maintained regularly and always be kept open. In case of emergency, it can be shut off promptly by a remote control device.

Second, the sounding pipes in the outside engine areas shall be with self-closing blanking device and self-closing control cock.

Third, a central control system involving various emergency shut off systems should be built and installed in easily accessible areas such as the muster station and bridge.

Fourth, emergency instruction that test and check the central control devices and emergency shut-off valve should be mandatory. Also, regular maintenance and drills should be observed.

This study proposed that improvement consideration from the perspective of equipment regulations and international standards, after the concept analysis, systems analysis, and problem analysis about the theme. The future, we will present a study on the results of research and characterized development matters in each.

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