Research on the Use of Oil Tankers' Return Space for Transport of Fresh Water (Part II)

In this study we investigate the modifications needed to be made to both the ship and wharf facilities to permit the loading and unloading of fresh water. Problems arising from those modifications are also considered. The article includes a case study of pump capacities and unloading times.

Loading and Unloading Facilities Required for Transport of Fresh Water

As oil tanker design is optimized for the transport of crude oil, use for transport of fresh water necessarily requires consideration of facilities for loading and unloading.

Fresh water transported in oil tankers as described in this paper serves as ballast on non-oil carrying voyages with a consequently low transport cost for the water itself. Thus, to be used for this purpose, tankers should require only a minimum of modification to existing on-board facilities.

The important points in connection with fresh water transportation by oil tankers are described below. In case of fresh water carriage in cargo oil tanks and/or ballast tanks, the position of overboard discharge outlet of effluents is important as explained in section 1.

When fresh water is transported in cargo oil tanks, another problem is the possibility of the fresh water being contaminated with residual oil in these tanks.

The pumps used to load and unload crude oil on a VLCC have a capacity of 12,000-18,000 m^3/h with a total head of 130-160 m, more than enough for unloading water into even large-scale reception facilities.

However, if water is transported in permanent ballast tanks, problems arise with the capacity of the pumps and piping. This is described in section 2 and later.

1. Position of Outlets in the Hull

The MARPOL 73/78 regulations require discharge of effluent from outlets above the waterline in the maximum ballasted condition. It is a matter of course, accordingly, that the water outlets in the hull of a tanker used to transport fresh water must be above the waterline when the water cargo is loaded. Consequently, the positions of the outlets must be raised in many vessels. This is not necessary for existing oil tankers using the part-flow system, but in new tankers, which are not permitted to use this system, the water outlets must be raised.

2. Ballast Tank Piping and Pump Capacities

Transport of fresh water in the SBTs (Segregated Ballast Tanks) of SBT tankers, or in the PBTs (Permanent Ballast Tanks) of COW tankers, is an ideal means of avoiding contamination by oil. Still, problems remain with piping and pump capacities.

SBTs and PBTs are ballast tanks used solely to ensure the required draught and so the capacity of the piping and related equipment is only sufficient to receive and discharge sea water. Piping used to load and unload fresh water, and the capacity of the pumps for unloading fresh water therefore requires additional consideration.

As sea water ballast is taken into the ballast tanks via inlets in the bottom of the hull, the relevant pumps and piping are positioned low. The capacity of these pumps in VLCCs is normally 4,000 $m^3/h \times 35$ m (head).

Therefore, to load and unload fresh water a piping system must be provided for loading into the tanks from deck level and unloading through pumps. As water cannot be pumped ashore with the pumps used in current tankers, the only solution is to unload onto barges. Pumps therefore require modification in order to unload fresh water.

1) Piping to load fresh water into ballast tanks

The only water piping on the upper deck of an oil tanker is that used for fire-fighting, which has a diameter of approximately 125 mm and cannot be used to load large volumes of fresh water. The following options may be considered.

(i) Use of portable hoses and installation of simple fresh water piping

Portable hoses for loading fresh water would be available at the loading point or carried on board. Hoses would be connected to the fresh water piping leading from the water source and inserted into a ballast tank hatch.

Water would flow from the first tank to others through the interconnected ballast piping due to the forces of gravity (see Fig. 1).

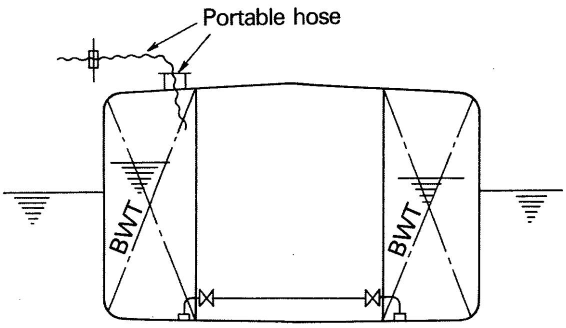

Fig. 1 Loading fresh water

If portable hoses are to be used, installation of special fresh water loading pipes (see Fig. 2) would be advisable. This piping would be located at both sides of the vessel to enable berthing on either side and to ensure safer loading of a large volume of water as compared with the use of hoses only.

Movement of water between tanks would be as described in (i).

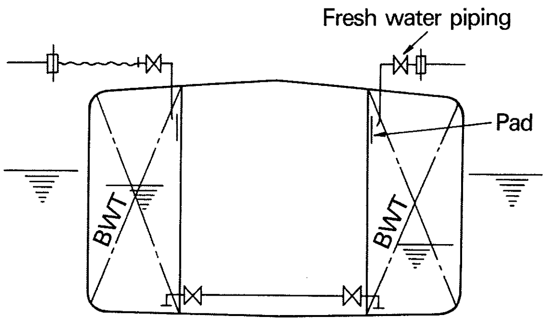

Fig. 2 Loading fresh water via piping

(ii) Piping for loading and unloading fresh water

If the transport of fresh water in ballast tanks becomes common procedure, the installation of permanent loading and unloading equipment would be desirable. This is described later in section 2.2) (ii).

2) Piping to unload fresh water from ballast tanks

(i) Use of portable hoses

Two methods have been proposed to unload fresh water using portable hoses. The portable hose is either placed directly into the ballast tank hatch and the water siphoned out as shown in Fig. 3, or a portable hose connector is fitted to the ballast tank outlet pipe with the hose passed through the vertical pump room entrance to the outside of the vessel, and the fresh water is unloaded with the ballast pump or with a siphon as shown in Fig. 4.

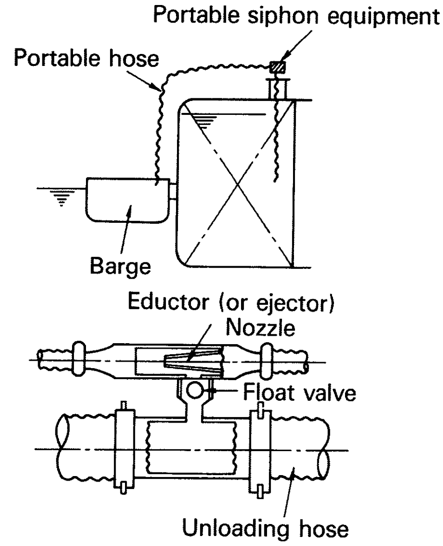

Fig. 3 Unloading water with portable hoses using siphons

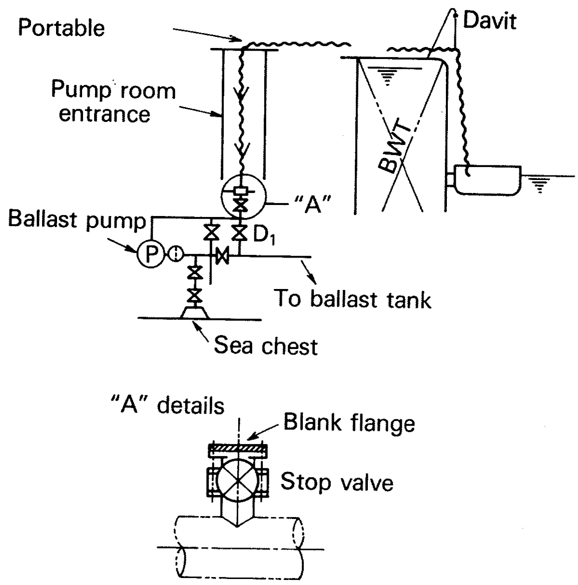

Fig. 4 Unloading water with portable hoses

As the siphon in Fig.3 may only be used until the water level in the ballast tank is reduced to a certain level, the remaining water in the tank will be wasted. Use of the pump as in Fig.4 is therefore essential.

With Fig.4, when the portable hose connector is not in use, it should be closed off with a blank flange (see details "A") and stop-valve for safety. As the portable hoses would be of very light synthetic resin, etc., for ease of handling, a remotely operated stop-

Artist's impression of a crude oil terminal region transformed by additional water supplies

valve would be installed outside the pump room to prevent flooding should the hose be damaged, and the ballast pumps would be stopped from outside the pump room as is the case with the crude oil pumps.

As sharp bends may result in damaged hoses and leaks, guides would be installed at the hose ends to limit bending (see Fig. 5).

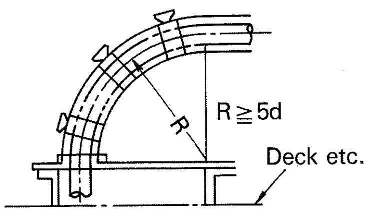

Fig. 5 Hose bend guide

(ii) Permanent piping

Ballast pumps on VLCC class tankers have capacities in the order of 3,500-4,500 m^3/h with a total head of 35-40 m, two pumps normally being fitted to SBT tankers, and one to non-SBT tankers.

The permanent ballast tanks of non-SBT tankers have capacities in the order of 35,000 m^3, ballast tanks of SBT tankers having capacities in the order of 85,000 m^3. They may therefore be emptied in 8-10 hours, but because of the low lift capacity as stated above intermediate pumps must be used for the transfer of water to tanks ashore. The following two methods have been proposed according to the scale of the unloading facilities.

(a) Poop-front fresh water header

As shown in Fig. 6, the fresh water header is installed in the poop-front, parallel to the fuel oil loading header. The barge mooring fittings and hose davits, etc., required for loading fuel oil are also used for loading and unloading fresh water.

The piping for the header and the vertical piping in the pump room are of steel with a nominal diameter of approximately 250 mm to allow unloading of approximately 1,000 m^3/h.

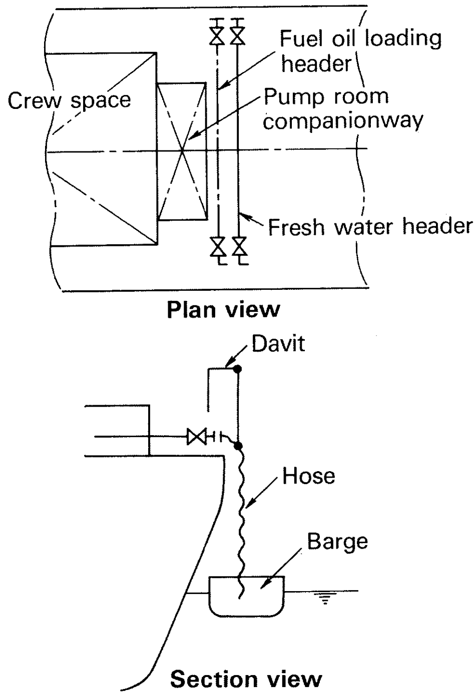

Fig. 6 Fresh water header (poop-front) example

(b) Midships fresh water header

As shown in Fig. 7, the fresh water loading or unloading header is installed amidships beside the crude oil manifolds. The equipment required for loading or unloading crude oil, such as hose handling derricks, is also used for fresh water. The fresh water header specifications should generally be suited to those of the equipment at the unloading point, however if they are based on those of the crude oil manifold the equipment will be able to be used at all unloading points.

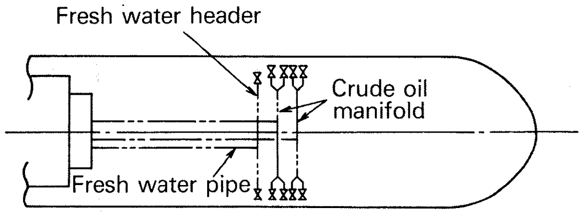

Fig. 7 Midships fresh water header example

3. Problems with Ballast Pumps of High Lift Capacity

As previously described, ballast pumps on VLCC class tankers have sufficient capacity, but as they are designed for raising water over relatively low heights, they are not suitable for direct unloading. Therefore, the water must be unloaded through pumps at intermediate points at sea, or through pumps having lift capacity as high as crude oil pumps.

Ballast pumps with high lift capacity eliminate restrictions on unloading points, yet the following problems are predicted.

1) Increased transport costs from new investments in high lift pumps

With newly constructed tankers, this additional investment amounts to 0.2-0.3 percent of total cost; with existing tankers it is considerably higher.

2) Problems with ballast pumps in non-optimal conditions

During ballasting, the ballast pumps are normally operated with a lift of no more than 10m. As the lift is proportional to the square of the pump speed, if the pump speed is halved, the lift is then a fourth, however as capacity is proportional to pump speed, capacity is also halved. Therefore, there are problems in the use of pumps with high lift capacity for ballasting.

3) Damage to ballast tanks

When high lift pumps are used for ballasting, considerable care is required to ensure that the ballast tanks do not overflow, resulting in abnormal pressures and damage to the tanks. Prevention of this damage would require rechecking the size of the ballast tank air pipes, etc.

4. Case study

Calculations of pump capacity and unloading times for a 259,600 DWT COW mode vessel A and a 257,882 DWT SBT mode vessel B are as shown below.

5. Use of Crude Oil Piping Equipment

Ballast and crude oil piping equipment are completely separate as a rule. However, emergency piping can be provided to temporarily connect ballast and crude oil pump inlets, and vice versa, to discharge ballast water using a crude oil pump in the event of a ballast pump malfunction.

The use of the emergency piping to unload fresh water from PBT or SBT tankers using the crude oil piping equipment is physically and technically possible, but raises the problem of contamination of the water by crude oil encrusted on the pipes. At present, this method is illegal except in the case of a ballast pump malfunction.

Results of case study

**Midships header method*

		Vessel A			Vessel B
Method		Portable hose (low lift pumps)	Permanent piping* (low lift pumps)	Permanent piping* (high lift pumps)	Permanent piping* (high lift pumps)
Number of pumps		1 set	1 set	1 set	2 sets
Pump capacity		4,200 $m^3/h \times 37$ m	4,200 $m^3/h \times 37$ m	4,000 $m^3/h \times 152$ m	4,000 $m^3/h \times 155$ m
Main outlet pipe	**Material**	Resin hose	STPY-41	STPY-41	STPY-41
	Outlet dia.	200 mm	500mm	500mm	650mm
	Specifications	Pressure resistance 7 kg/cm^2 (normal use) Weight 11.1 kg/m	t = 7.9 mm Galvanized	t = 12.7 mm Galvanized	t = 12.7 mm Galvanized
Average lifting capacity		1,000 m^3/h	3,950 m^3/h	4,000 m^3/h	8,000 m^3/h
Fresh water capacity		35,800 m^3	35,800 m^3	38,000 m^3 (including AP tank)	85,000 m^3 (including AP tank)
Lifting time		35.8 h	9.1 h	9.5 h	10.6 h