Application Bulletin – Shipbuilding Industry
PIPENET® Transient Module Case Study

CHARGING AND DISCHARGING OF BALLAST TANKS ON SHIPS

INTRODUCTION

In this document we consider charging and discharging of ballast tanks on ships and transferring ballast water between tanks located on different parts of the ship. Hence, the following four scenarios are analysed:

1. Charging top level ballast tank from the sea chest. We assume that the pressure (or head) in the sea chest has a sinusoidal pattern in order to model the wave pattern. It is possible to consider that more complex variation in the pressure in the sea chest is possible but this was not considered in this document.
2. Transferring ballast water from low level ballast tank to high level ballast tank. We assume that this takes place in a port and so the wave pattern in draft is not considered.
3. Discharging the top level ballast tank back to the sea by opening bypass valves around the ballast pumps.
4. Transferring ballast water from multiple low level ballast tanks to multiple high level ballast tanks.

In all scenarios we assume that tanks are being fed at the bottom.

Naturally, PIPENET can be used for modelling fluid flow during cleaning of the ballast tank sediment. We do not consider this in this application.

BALLAST TANK PROFILE

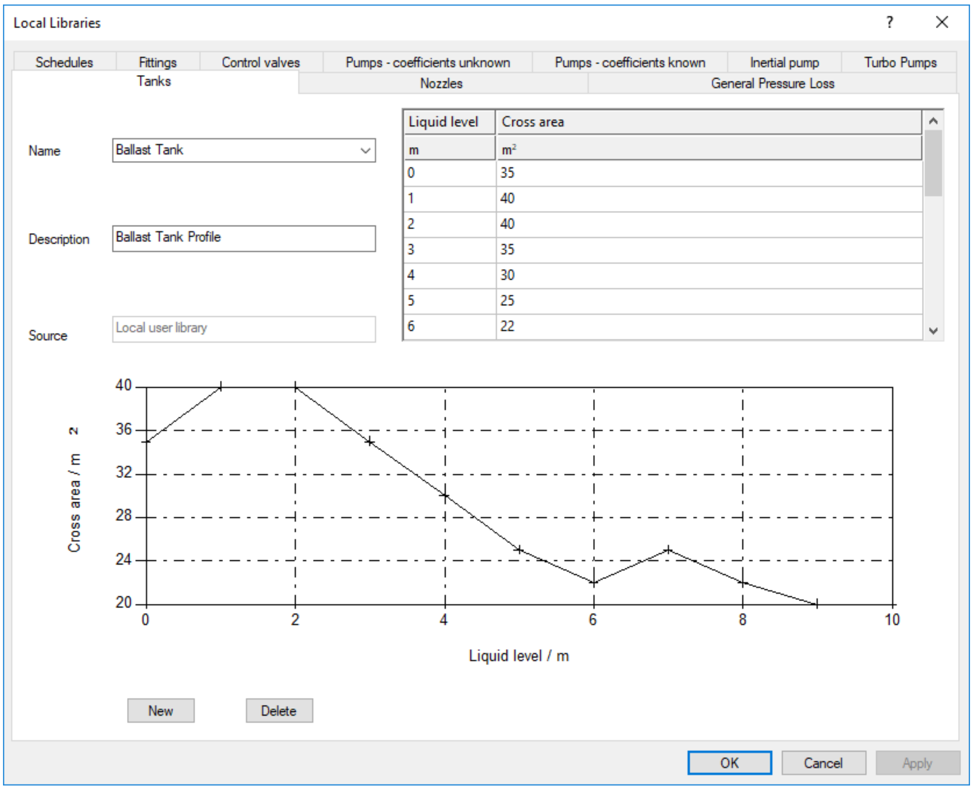
The shape of the tank may not be simple because it has to follow the shape of the hull. Alternatively, the space within the double hull can be used for ballast purposes. This may also have a complex shape.

The following assumptions have been made in this study:

- Top level ballast tank has a capacity of 314 m^3 of seawater.
- Nominal diameter of the main pipe used for filling the top level ballast tank is 400 mm.
- Draft in the sea chest is an average of 15 m. It is assumed that the wave pattern of the sea creates a sinusoidal change in the draft in scenario 1. It is assumed to remain constant in scenarios 2 – 4.
- Base of the high level ballast tank is 45 m above the sea chest
- Pipe is connected to the bottom of the ballast tank.
- Initial water level in the high level ballast tank is 1 m.
- The top level ballast tank is assumed to be of non-uniform cross-section. The area of cross-section of the ballast tank against its height is shown in the table below.

Height, m	Area of cross-section, m^2
0	35
1	40
2	40
3	35
4	30
5	25
6	22
7	25
8	22
9	20
10	20

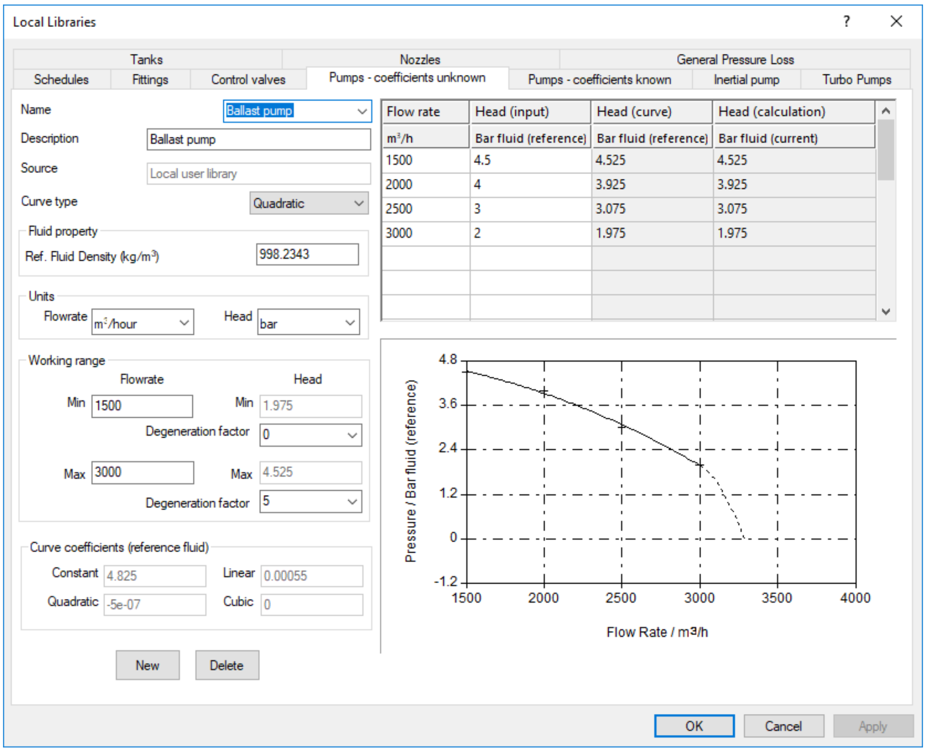
PIPENET dialog box for defining the shape of the high level ballast tank is shown below.



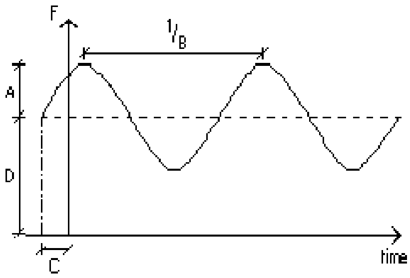
Pump performance curve is shown below.

Pump flowrate, m^3/hr	Pressure, bar
1500	4.5
2000	4
2500	3
3000	2

PIPENET dialog box for pump curve:



The draft of the sea chest is assumed to have a sinusoidal profile against time. This is the simplest pattern but other patterns can also be defined in PIPENET.



$$F = D + A\sin 2\pi B(t + C)$$

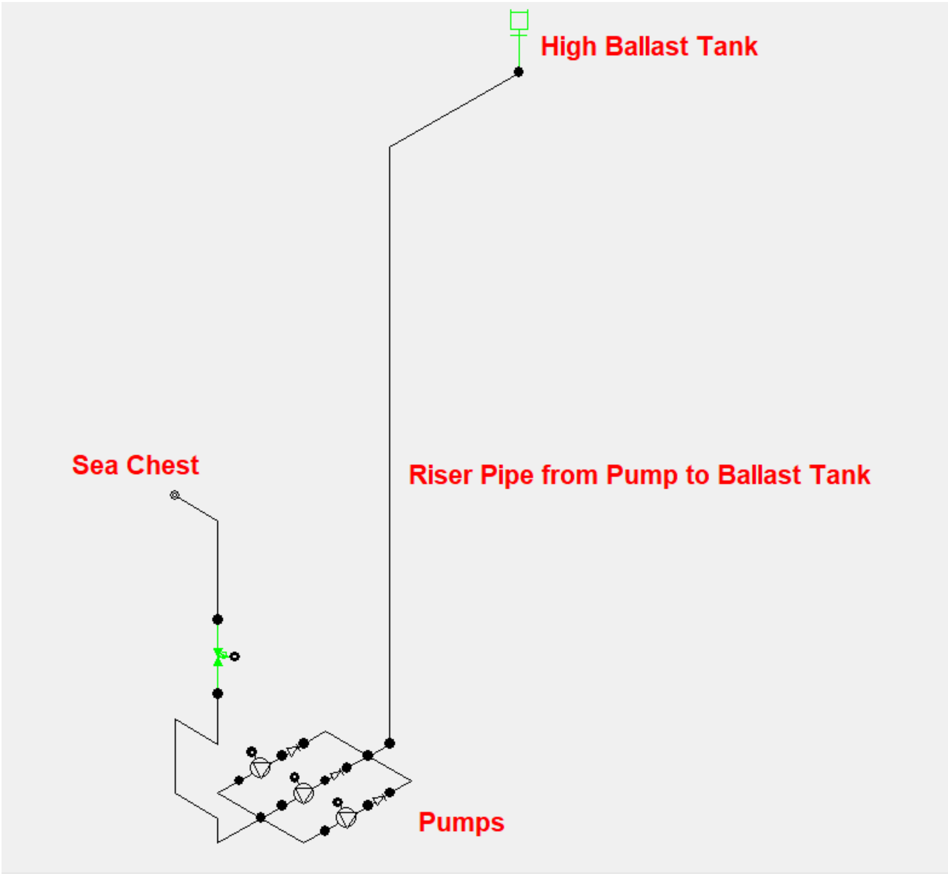
Label	1	
Input/Output node	YES	
Results selected?	NO	
Specification Type	Pressure	
Time Function	Sine wave	
Amplitude	3	m fluid G
Frequency	0.016667	1/sec
Constant phase s...	0	sec
Constant	15	m fluid G

D = 15 m
A = 3 m
B = 1 sec
C = 0 m

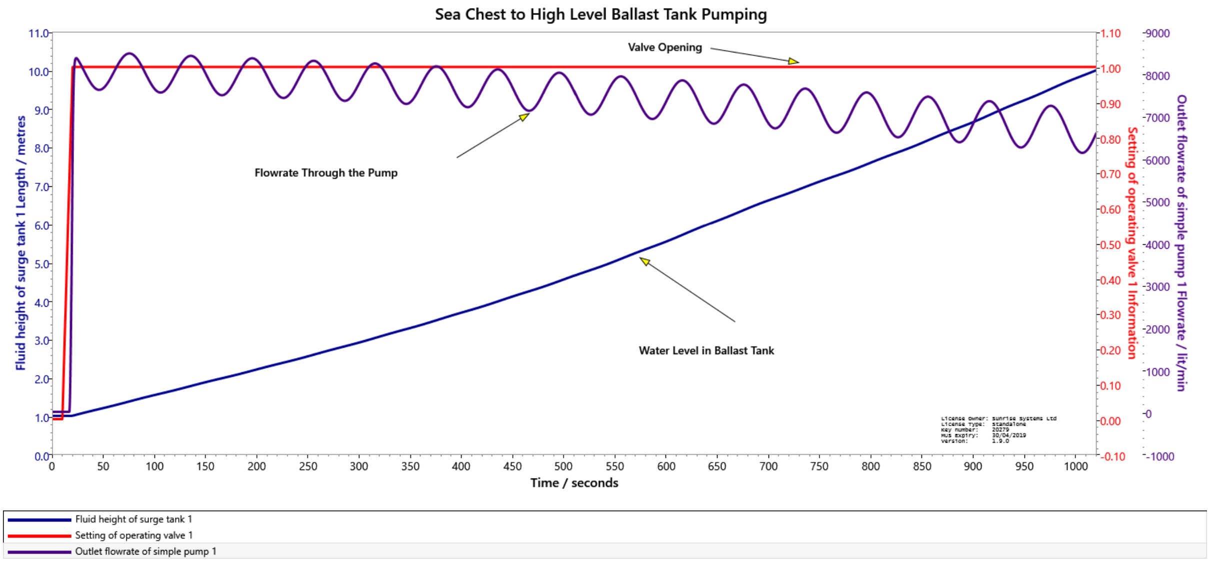
	Surge tank	
Label	1	
Input node	6	
Type	Ballast Tank	
Height	10	m
Initial Fluid Depth	1	m
Roughness	4.57e-05	m
Results selected?	YES	

SCENARIO 1: SEA CHEST TO HIGH LEVEL BALLAST TANK PUMPING.

The network drawing:



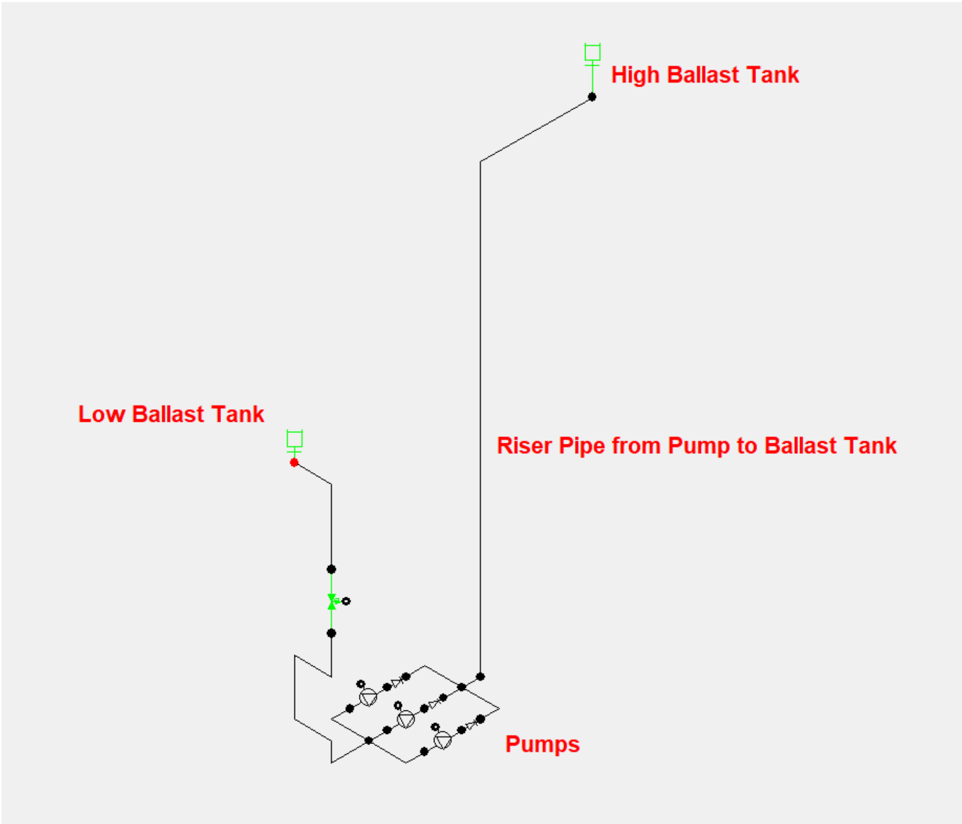
The results are shown in the following graph.



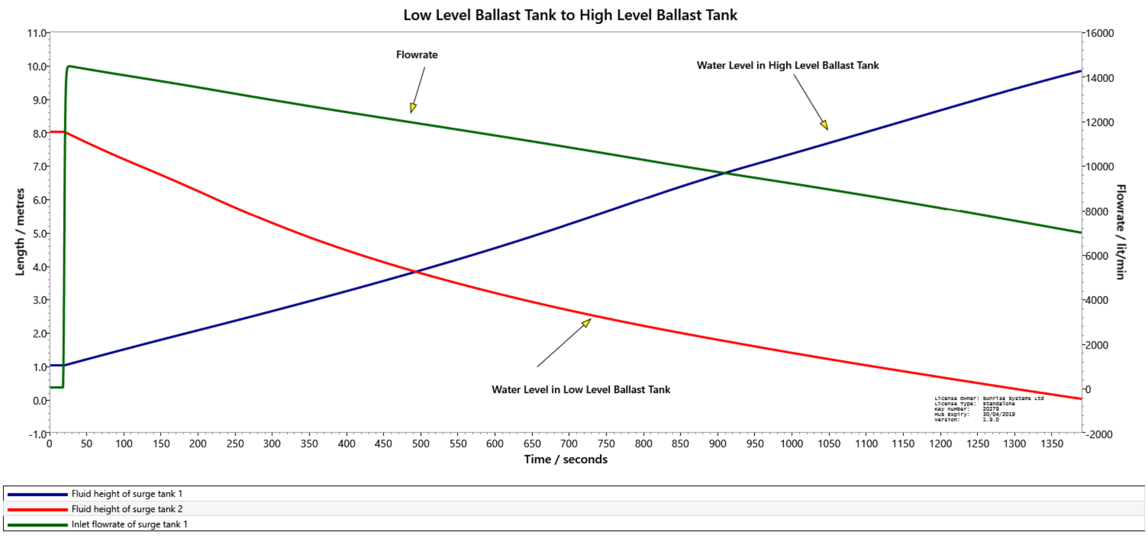
It can be seen that the high level ballast tank takes around 1020 secs (17 minutes) to fill up to the top. It is also interesting to see that the flowrate through the pump decreases slowly. The oscillations in the flowrate through the pumps happen because of the draft changing with sinusoidal pattern.

SCENARIO 2: LOW LEVEL BALLAST TANK TO HIGH LEVEL BALLAST TANK PUMPING.

The network drawing:



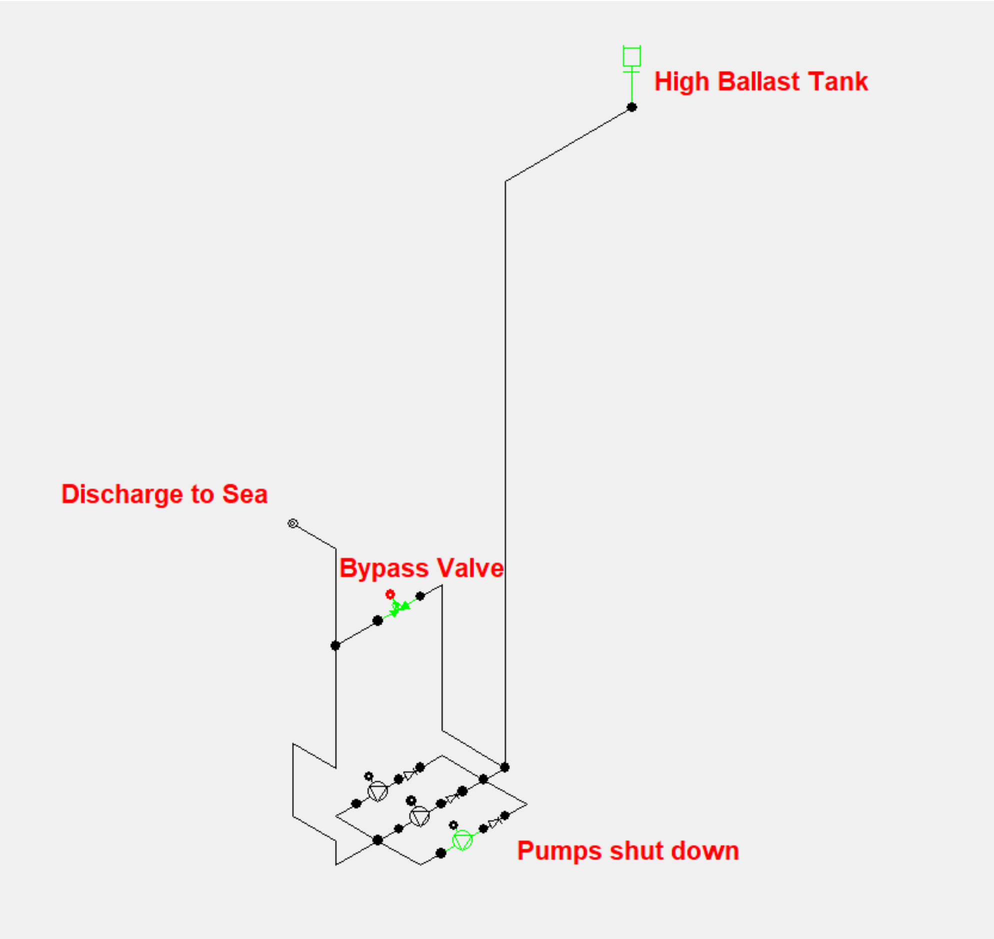
The results can be seen in the following graph.



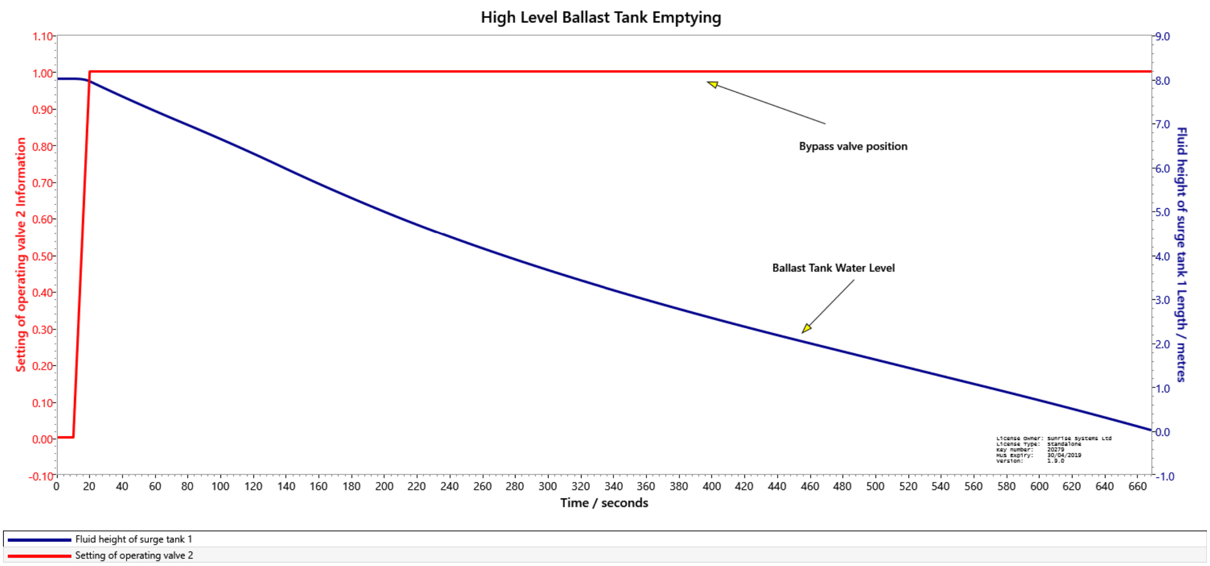
The low level ballast tank has an initial water depth of 8 m. The high level ballast tank has an initial water depth of 1 m. It can be seen in the graph that the low level tank empties before the high level tanks gets full. This is because the amount of water is less in the low level tank. It can also be seen that the flowrate decreases as the low level ballast tank empties and the high level ballast tank gets filled up.

SCENARIO 3: HIGH LEVEL BALLAST TANK DISCHARGING BACK TO THE SEA

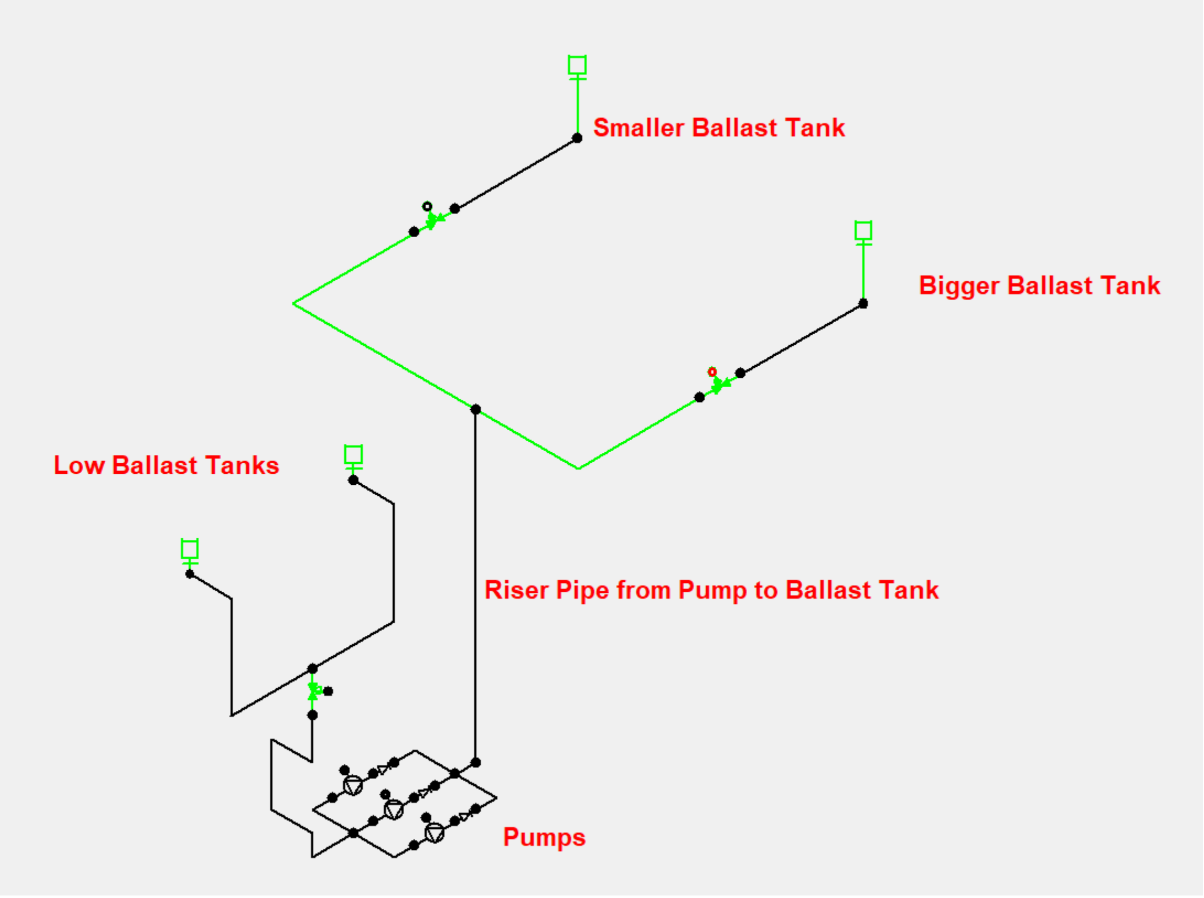
In this case we consider the high level ballast tank discharging water to the sea. The outlet is assumed to discharge direct to the sea rather than the sea chest. The tank has an initial water depth of 8 m.



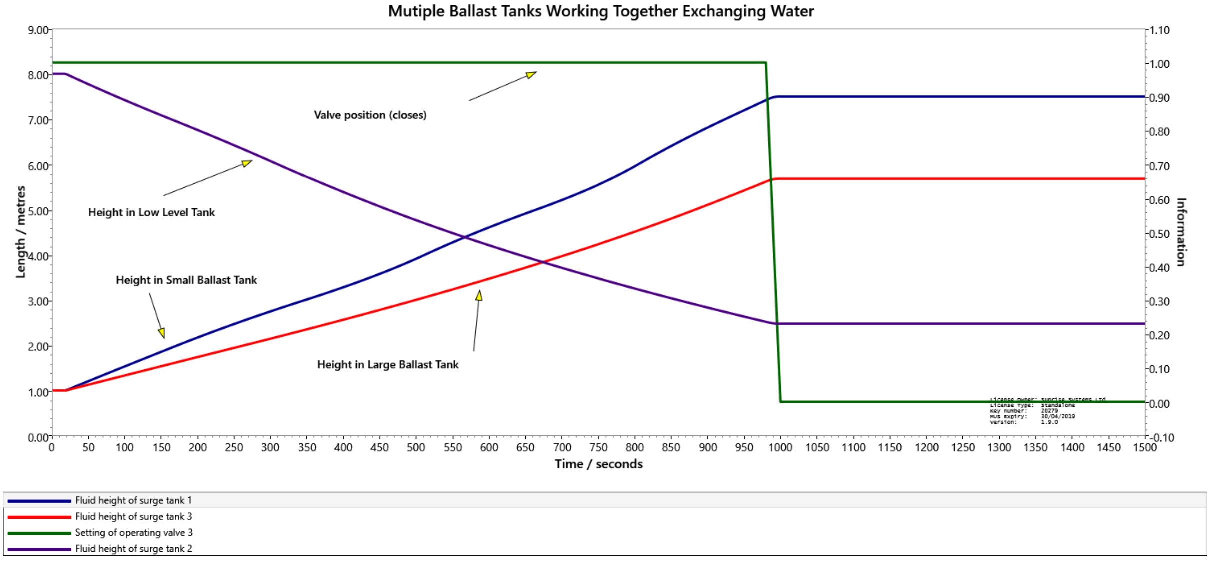
The results are shown in the following graph. It can be seen that the ballast tank discharges in about 668 secs (approx. 11 minutes).



SCENARIO 4: MULTIPLE LOW LEVEL BALLAST TANKS TO MULTIPLE HIGH LEVEL BALLAST TANKS.



The results can be seen in the following graph.



Three pumps take water from two low level ballast tanks and move it to two high level tanks. The two high level ballast tanks have different shapes and one is smaller than the other.

CONCLUSIONS

We have seen that PIPENET Transient Module can be successfully used to model charging and discharging of ballast tanks on ships and transferring ballast water between tanks located on different parts of the ship.

If you have any questions about this case study, or any other of PIPENET's capabilities, please email us at Pipenet@sunrise-sys.com.