3.1 Cargo Tanks

This vessel has 17 cargo tanks and is located in front of Pump Room.

The specification of cargo tanks is shown in Table 3.1.

The setting pressures of each pressure/vacuum valve are defined so as not to be more than the allowable cargo tank ullage pressure as the Table 3.1, i.e. these setting pressures are defined considering to some safety factors, so that the tank structural failure due to over /under pressure does not occur.

Table 3.1 List of Cargo Tanks and Setting Pressure of Cargo Tank Venting System

Tank No.	Capacity (m3) (98 %)	Allowable Ullage Pressure (MPa)	Setting Pressure of PV Valve* (MPa)		Setting Pressure of PV Breaker* (MPa)		Setting Pressure of Pressure Alarm (MPa)	
			Pressure Side (min.)	Vacuum Side (max.)	Pressure Side (min.)	Vacuum Side (max.)	High Pressure (MPa)	Low Pressure (MPa)
No. 1 (P/S)	16,255.0	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 2 (P/S)	20,198.8	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 3 (P/S)	20,198.8	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 4 (P/S)	20,198.8	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 5 (P/S)	14,244.6	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 1 (C)	27,673.1	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 2 (C)	31,886.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 3 (C)	31,886.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 4 (C)	31,886.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
No. 5 (C)	31,886.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
Slop (P)	3,832.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
Slop (S)	3,832.4	0.014	0.014	0.0035	0.018	0.007	0.015	0.005
(Total)	345,187							

* Names of Pressure / Vacuum relief systems and their setting pressures are to be shown in applicable boxes.

3.2 Cargo Tank Venting System

a) The vessel is provided with the inert gas supply main and this is also used for the control of cargo vapour release (See Chapter 4). This line is fitted with branch piping leading to each cargo tank. Branch piping for inert gas is fitted with either stop valves or equivalent means of control for isolating each tank. The stop valves are provided with locking arrangement, which is under the control of a responsible vessel's officer.

In addition, the vessel has the independent vent post with the high velocity relief/vacuum valve for each cargo tank. This system also enables thermal breathing from cargo tanks when the isolation valve is closed.

A liquid-filled P/V breaker is typically connected to the cargo tank venting/inert gas main. The P/V breaker has a capacity to accommodate the gas flow from cargo tanks during loading (125% of the loading rate and discharge rate).

The cargo tank venting/inert gas main is typically used during loading and discharging operations. During loading the mast riser valve is open (unless vapour emission control is performed) and VOC is expelled to air. During discharge the same valve is closed and inert gas used to replace the tank atmosphere.

The detail of the venting system can be found in "13.4 Piping Diagram of Cargo Tank Vent/Inert Gas System.

b) In addition, the vessel is provided with "Vapour Emission Control. The purpose of the system is to return the vapour containing VOC to shore terminal not to relief the vapour to atmosphere in ports/terminals.

To comply with the VECS requirement of USCG CFR, the vessel is provided with Vapour Return Line and its Manifold, pressure sensors and their alarms, high level alarms and tank overfill alarms, etc…

For the detail of on VECS system and this operation, it can be found in "Operation and Equipment Manual for Vapour Emission Control System [dwg. No.DA800D111]". This manual also shows the maximum allowable loading rate with max. vapour densities.

3.3 Inert Gas System

The vessel is provided with the inert gas system and the inert gas supply main is also used as cargo vent common line. The system is capable of delivering inert gas to the cargo tanks at a rate of at least 125% of the maximum rate of discharge capacity of the vessel expressed as a volume.

The purpose of inert gas system is inerting in the cargo tanks and relevant pipe lines during loading/unloading/voyage to change from explosive atmosphere to non-explosive atmosphere. However, adding inert gas into cargo tanks, it is possible to relief the mixture of inert gas and VOC to atmosphere acting pressure/relief valve and/or PV Breaker.

The detail of inert gas system can be found in “Operation and Equipment Manual for Vapour Emission Control System [dwg. No.DA800D111]” and “Flue Inert Gas System Manual [OSP. No. IG110101B6C8-OHJW0S]”

3.4 Crude Oil Washing System

The vessel is provided with the fixed type of crude oil washing system. The purpose of the system is to wash in the cargo tanks by crude oil using not only cleaning effect of physical spray impact but also crude oil chemical characteristics to dissolve the sludge such as waxes or asphalt in crude oil. However, cargo vapour generates as a result of the Crude Oil Washing of the cargo tanks.

The detail of crude oil washing system can be found in “13.5 Piping Diagram of Crude Oil Washing” as attached, and can make reference to “Crude Oil Washing System Manual [dwg. No. DA800D113] which is placed onboard the vessel”.

3.5 Vapour Emission Control System – Design and Specification

a) When loading of cargoes, oil vapour from cargo tanks to be well managed to avoid over pressure in the tanks. For this purpose, following principle functions are provided and installed.
   - Individual vent through H/V P/V valve on each tank
   - Vent riser connected to I.G.S main (common free flow venting system)
   - Crossover manifold to shore connected to I.GS main which as a part of VECS requirement.

b) As demanded by USCG 46 CFR Part 39, this manual described mainly design and installations related the crossover manifold connected to IGS main as Vapour collecting piping.

c) IG system on this vessel is designed based on discharging capacity of 15,000 M3/H from ship when Cargo Oil Pumps are running on each segregation of cargo discharging piping. This concept result that IGS plant and its associate piping is able to handle 19,000 N M3/H of Inert Gas from the plant. Before the VECS operation, IG001 valve to be closed for the

separation / isolation of IG plant / piping and VECS piping as required by USCG 46 CFR Part 39.20 -1(a)(6).

d) VECS collecting piping is commonly used with I.G supply piping when loading and connected to cross over shore manifold by which oil vapour in cargo tanks during loading can be transferred to shore.

- Diameter of vapour main to shore: ND 600
- Diameter of vapour branch from each tank to main: ND 300
- Material of vapour piping:
  Main: steel 2.7t,
  Branch: steel sch. 80
- Vapour piping is electrically bonded to the hull by using toothed washer on the flange joint and anchor point to the hull.
- Drain/condensate from the vapour main piping is returned to slop tank naturally/ gravitationally via inert gas branch pipes.

e) Vapour connection

- Vessel vapour connection is located fore and abaft of midship cargo manifold PORT and STBD in accordance with OCIMF.
- Refer Chapter 13 - Appendix of this manual for location of vessel vapour connection.
- Vessel vapour connection is labelled and coloured as required by USCG 46 CFR Part 39.20-l (d) i.e. red / yellow / red colour with "VAPOUR" in black letter.

f) Flange and fitting

- At the vessel vapour connection, 16"(400A) ANSI B16.5 Classl50 Flange are provided.
- Two reducers, at same specification of 12" (300A) connections are stored on board.
- 0.5-inch diameter and 1 inch length of stud as fitted on the face of flange and reducer.
- Vapour connection in the cargo manifold area is installed according to OCIMF "Recommendation for Oil Tanker Manifold and Associated Equipment”

g) Hoses

Builder does not provide Hoses transferring vapours from vessel vapour connection to shore. However, the owner or operator of the vessel may provide / carry flexible hoses suitable to use as demanded by USCG 46 CFR Part 39.20-l (f).

h) Tank Gauging System

- Each cargo tanks and slop tanks are fitted with closed gauging designed and supplied by SAAB.
- Intrinsically safe type high level alarms are set at corresponding level to 95% volume of the tank (HIGH LEVEL ALARM).
- In addition, portable gauging is also provided in connection with demands from hand dipping on the field of crude oil washing. Each tank is provided 2". Deck seal value for portable gauging that can detect ullage, interface and temperature.
- Refer Chapter 13 – Appendix of this manual and maker's drawing / manual separately retained on board, for further detailed technical information.
- Tank level gauging is displayed on the centralized console in cargo control room and local on the deck.
- Legend as required by USCG 46 CFR Part 39.20-7(c)(2) is provided on cargo control console.

i) Independent overfill alarm

- Independent overfill alarm designed and supplied by SAAB is also provided and installed in each tank set at 98% level of each tank.
- Overfill alarm present audible and visible signal to cargo control room and deck area. Electric flashing light and horn is provided on the flood light post on deck.
- Refer Chapter 13 – Appendix of this manual and maker's drawing / manual separately retained on board, for further detailed technical information.
- Legend as required by USCG 46 CFR Part 39.20-7(d) (3) is provided on cargo control console.
- Power failure alarm as required by USCG 46 CFR Part39.20-7(b) is provided on cargo control console.

j) Vapour pressure / oxygen alarm

- Vapour pressure monitoring system designed and supplied by HANLA LEVEL CO. LTD. and oxygen alarm system supplied by owner for the provisions as required for lightering operation.
- Pressure and oxygen detection is taken from the source on vapour piping near the midship area and alarm indication is displayed in the Cargo Control Room.
- High-Pressure alarm is set at +1200mmwg.
- Low-pressure alarm is set at +100mmwg.
- Refer Chapter 13 – Appendix of this manual and maker's drawing / manual separately retained on board, for further detailed technical information.

k) Pressure vacuum valve

- High velocity P/V valve is fitted on each cargo tanks and slop tanks.
- Diameter of P/V is ND 250 fitted to ND 250 standpipe.
- Design intention of high velocity P/V valve on each tanks are:
  I. To cover breathing effect during cargo voyage due to thermal variation.
  II. Vapour escaping, when loading, where this kind of venting is allowed. For this purpose accumulating of vapour gas as demanded USCG was considered from design.
- Setting of high velocity P/V valve is:
  I. 0.14 kg/cm^2 at pressure side.
  II. 0.035 kg/cm^2 at vacuum side.
- Based on the cargo piping design which is 20,500 M^3/H from shore when 2 tanks are en gaged in every segregation of cargo piping, result of the design base of P/V valve capac ity based on 3,420 M^3/H. Loading of liquid cargo into any cargo tank is 6,341 M^3/H of ga s vapour evacuation from a tank, according to recent USCG demand. P/V valve on this vessel meet this recent USCG requirement.

l) Alarm List

ALARM	SIGNAL	ALARM AT	LOCATION
HIGH LEVEL ALARM	VISIBLE / AUDIBLE	95% each tank	CCR
OVERFILL ALARM	VISIBLE / AUDIBLE	98% each tank	Deck/CCR
VAPOUR MAIN LINE PRESSURE PROTECTION	VISIBLE / AUDIBLE	P (1200mmWG) V (100mmWG)	CCR

CCR: Cargo Control Room

m) Lightering operation
Oxygen analyzer and alarm is provided to meet USCG demand for lightering operation. Electrical insulating of flange is to be achieved when vapour hoses are fitted by means of current continuing strip wire. Detonation arrester is not fitted within 3M of the vessel vapour connection with alarm indication in Cargo Control Room. See operational requirement for lightering operation.

n) Setting of P/V breaker on I.G. main

- Capacity: 19,000 M^3/H
- Opening pressure: 1800mmWG
- Opening vacuum: 700mmWG

o) P/V valve pressure relieving capacity

$Q_a = Q_1$ X VGR X Root ($P_{v\text{-}a,115} \div P_{a,115}$)

where;

Q_a	Required air equivalent volumetric flow rate (M3/H)
Q_1	Loading Rate to each tank *(*3,420 M3/H as design base of building specification)
VGR	Growth rate of crude oil vapour - air mixture 1 + 0.25 X ($P_{v,115} \div 12.5$*)* = 1.003 (1.25 taken as VGR)
$P_{v,115}$	Saturated vapour pressure for crude oil at 115 °F = 0.15
$Þ_{v\text{-}a,115}$	Crude oil vapour - Air weight density at 115 °F
$Þ_{a,115}$	Air weight density at 115°F
$S.G_v$	Specific gravity of crude oil vapour (3.4)
$V_{v,115}$	Partial volume of crude oil vapours at 115°F (specified by the USCG to be taken as 50%)
$V_{a,115}$	Partial volume of air at 115°F (specified by the USCG to be taken as 50%)
$P_{v\text{-}a,115} \div P_{a,115}$	(SG_v) X $(V_{v,115})$ + $V_{a,115}$ = 3.4 X 0.5 + 0.5 = 2.2
Q_a	3,420 X 1.25 X Root 2.2 = 6,341 M3/H

p) P/V valve vacuum relieving capacity
Based on USCG requirement for the vacuum relieving capacity; no growth rate on the vapour density correction is necessary. Accordingly the P/V valve vacuum relieving capacity prevents a vacuum caused during maximum liquid discharge that exceeds the maximum design for any tank connected the vapour collection system.

Notes:
1) Vacuum side of P/V valve on this ship is designed to cover thermal breathing during cargo voyage.
2) During cargo Discharge operation, running of Inert Gas System is essentially required.

3.6 Vapour Emission Control System - Related Equipment

a) Inert Gas system (KANGRIM)

- IGS system on this vessel is designed based on discharging capacity of 15,000 M3/H from pumps. This concept result that IGS plant and its associate piping is able to handle 19,000 N M3/h of Inert Gas from plant.

- VECS collecting piping is commonly used with IG supply piping when loading and connected to cross over shore manifold by which oil vapour in cargo tanks during loading can be transferred to shore.

- Before the VECS operation, IG001 valve to be closed for the separation / isolation of IG plant / piping and VECS piping as required by USCG 46 CFR Part 39.20-1(a)(6).

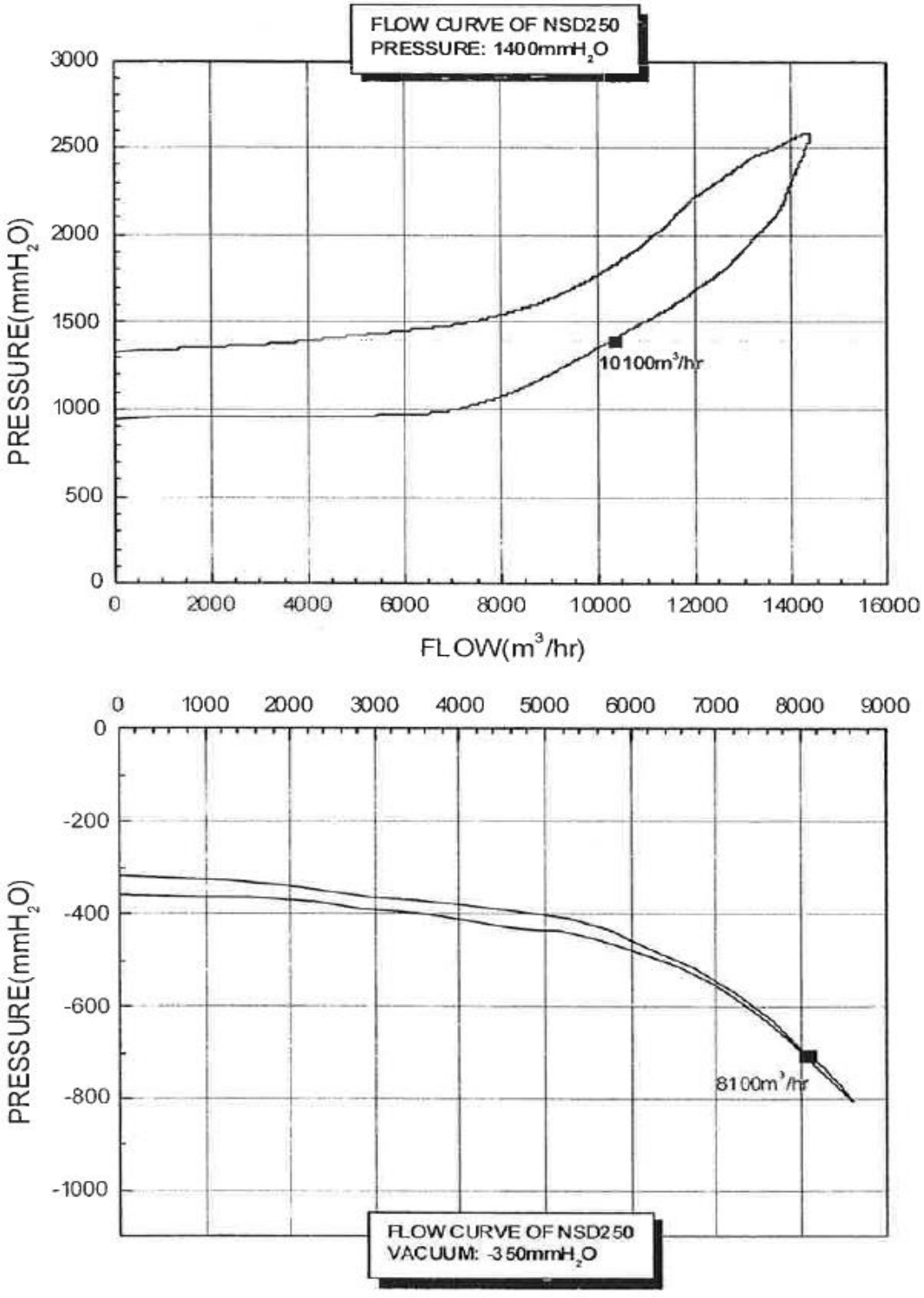
--- This sentence have been described on the IGS manual retained on board separately, as required by USCG 46 CFR Part 32.53-85(b). ---

- Full set of manual and drawing (DV376D101) is retained on board separately as AS BULIT DRAWING of which key – excerpted –copies relating VECS design and operation is enclosed in this manual for quick & easier reference.

b) H/V Pressure / Vacuum Valve (SEWON)

- High velocity P/V valve is fitted on each cargo tanks and slop tanks.
- Diameter of P/V valve is ND 250 fitted to ND 250 standpipe.
- Design intention of high velocity P/V valve on each tanks are:
  I. To cover breathing effect during cargo voyage due to thermal variation.
  II. Vapour escaping, when loading, where this kind of venting is allowed. For this purpose, accumulation of vapour gas as demand USCG was considered in the design.
- Setting of high velocity P/V valves are:
  I. 0.14 kg/cm^2 at pressure side
  II. -0.035 kg/cm^2 at vacuum side
- Full set of manual and drawing (DV374D101) is retained on board separately as AS BUILT DRAWING of which key – excerpted – copies relating VECS design and operation is enclosed in this manual for quick & easier reference.

NSD Type High Velocity Pressure/Vacuum Valve



c) Cargo Tank Level Gauging (SAAB)

- Each cargo tanks and slop tanks are fitted with radar beam principle closed gauging designed and supplied by SAAB products.
- Intrinsically safe type high level alarms are set at corresponding level to 95% volume of the tank (HIGH LEVEL ALARM).
- In addition, portable gauging is also provided in connection with demands from Hand dipping on the field of crude oil washing. Each tank is provided 2" Deck seal value for portable gauging that can detect ullage, interface and temperature.
- Refer APPENDIX of this manual and marker's drawing / manual separately retained on board, for further detailed technical information.
- Tank level gauging is displayed on the centralized console in cargo control room and local on the deck.
- Full set of manual and drawing (DV381D101) is retained on board separately as AS BUILT DRAWING of which key – excerpted – copies relating VECS design and operation is enclosed in this manual for quick & easier reference.
- Legend as required by USCG 46 CFR Part 39.20-7(c)(2) is provided on cargo control console.

d) Vapour pressure monitoring system (HANLA LEVEL) & oxygen alarm system

- Vapour pressure monitoring system designed and supplied by HANLA LEVEL and oxygen alarm system supplied by owner to meet demand for lightering operation.
- Pressure and oxygen detection is taken from the source on vapour piping near the mid-ship area and alarm indication is displayed in the Cargo Control Room.
- Full set of manual and drawing (DV382D101) is retained on board separately as AS BUILT DRAWING of which key – excerpted – copies relating VECS design and operation is enclosed in this manual for quick & easier reference.
- Refer APPENDIX of this manual and marker's drawing / manual separately retained on board, for further detailed technical information.
- Oxygen analyzer and alarm is provided to meet USCG demand for lightering operation. Electrical insulating of flange to be achieved when vapour hoses are fitted by means of current continuing strip wire. Detonation arrester is not fitted onboard since this ship is provided with Inert Gas System. Oxygen sampling connection is fitted within 3M of the vessel vapour connection with alarm indication in Cargo Control Room.

e) Independent high level alarm (SAAB)

- Independent overfill alarm designed and supplied by SAAB is also provided and installed in each tank set at 98% level of each tank.

- Overfill alarm present audible and visible signal to cargo control room and deck area. Flashing light and horn are provided on the flood light post on deck.

- Refer to Chapter 13 – Appendix of this manual and maker's drawing / manual separately retained on board, for further detailed technical information.

- Full set of manual and drawing (DV381D106) is retained on board separately as AS BUILT DRAWING of which key – excerpted – copies relating VECS design and operation is enclosed in this manual for quick & easier reference.

- Legend as required by USCG 46 CFR Part 39.20-7(d)(3) is provided on cargo control console.

- Power failure alarm as required by USCG 46 CFR Part 39.20-7(b) is provided on cargo control console.

f) Lightering Operation – Operation Requirement *(Only For Information)*

- During a lightering or topping off operation each cargo tank being loaded must be connected by the vapour collection system to a cargo tank, which is being discharged.

- If the cargo tanks on both the vessel discharging cargo and the vessel receiving cargo are inerted, the following requirements must be met:

  I. Each tank on a vessel receiving cargo, which is connected to the vapour collection system, must be tested prior to cargo transfer to ensure that the oxygen content in the vapour space does not exceed 8 percent by volume. The oxygen content of each tank must be measured at a point one meter (3.28 feet) below the tank top and at a point equal to one-half of the ullage. Where tanks have partial bulkheads, the oxygen content of each area of that tank formed by each partial bulkhead must be measured at a point one meter (3.28 feet) below the tank top and at a point equal to one-half of the ullage;

  II. The oxygen analyzer, required by §39.40-3(a) must be tested for proper operation prior to the start of each transfer operation;

  III. The oxygen content of vapours being transferred must be continuously monitored during the transfer operation;

  IV. Cargo transfer must be terminated if the oxygen content exceeds 8 percent by volume and must not be restarted until the oxygen content in the tanks of the vessel receiving cargo is reduced to 8 percent by volume or less; and

  V. The vapour transfer hose must be purged of air and inerted prior to starting vapour transfer.

- The isolation valve required by §39.20-1(c) of this part, located on the service vessel must not be opened until the pressure in the vapour collection system on the vessel

receiving cargo exceeds the pressure in the vapour collection system on the vessel discharging cargo.

- The cargo transfer rate must be controlled from the vessel discharging cargo, and must not exceed the maximum, allowable transfer rate for the vessel receiving cargo.

- The pressure in the vapour space of any cargo tank connected to the vapour collection line on either the vessel receiving cargo or the vessel discharging cargo must not exceed 80 percent of the lowest setting of any pressure relief valve during ballasting or cargo transfer.

- All impressed current cathodic protection systems must be de-energized during cargo transfer operations.

Tank washing is prohibited unless the cargo tanks on both the vessel discharging cargo and the vessel receiving cargo are inerted or the tank is isolated from the vapour collection line.