Tankers

Manuel Ventura

Ship Design I

MSc in Marine Engineering and Naval Architecture

Main Types of Tankers (1)

- **Oil Tanker** – tanker for the carriage of crude-oil
- **Shuttle Tanker** - tanker ship for the carriage of crude-oil directly from the offshore oil fields to terminals or refineries.
- **Product Tanker** - tanker for the carriage of refined products derived from crude oil (gasoline, Diesel oil, jet fuel) from the refineries.

Main Types of Tankers (2)

- **Chemical** *(Parcel Tanker)* – tanker for the carriage of chemical products in bulk.
  - Simultaneous carriage of different types of cargo
  - More recent ships are equipped with clad tanks (steel coated with stainless steel) or completely built in stainless steel.
  - Can carry a large number of different types of cargo
  - Each tank has its own load/discharge system with separate pumps and piping systems.

Main Types of Tankers (3)

- **Liquefied Gases** – tanker for the carriage of condensed gases
  - The gases are kept in the liquid state due to high pressures or to very low temperatures, in tanks with highly efficient insulation.
  - More relevant cargo types:
    - **LNG** (*Liquefied Natural Gas*) - mainly methane, with temperatures that can reach the –163 °C.
    - **LPG** (*Liquefied Petroleum Gas*) - This gases have a low boiling point (-44 to 0°C) and high vapor pressure. They are carried at environment temperature in pressurized tanks independent from the ship's hull, or at reduced temperatures, at atmospheric pressure.

      Examples: propane, butane, propylene, butylene

Oil Tankers

Oil Tankers – Typical Sizes

Products tanker for refined products with 35,000 t < DW < 70,000 t. Average price abt. 32 Mill. US$

Handysize 20,000 t < DW < 30,000 t

HandyMax DW ~ 45,000 dwt

Aframax 80,000 t < DW < 119,000 t (*American Freight Rate Association*). Average price abt. 44 Mill. US$.

Suezmax the largest tanker that can cross the Suez Canal, fully loaded (120,000 t < DW < 180,000 t). Average price abt. 54 Mill. US$

VLCC (Very Large Crude Carrier) 260,000 t < DW < 330,000 t. Average price abt. 85 Mill. US$.

ULCC (*Ultra Large Crude Carrier*) DW > 330,000 t.

Ships on Order (2010)

Tanker Orderbook 24/09/2010 Number of ships

	2010 (deliv.)	2010	2011	2012	2013	2014	2015+	Total on order
VLCC	41	25	78	57	29	9	0	**198**
Suezmax	29	25	54	55	20	2	0	**156**
Aframax	53	31	77	44	7	3	0	**162**
Panamax	22	13	43	16	10	2	0	**84**
MR Product	85	62	102	56	8	0	0	**228**
Handy Product	19	11	25	11	0	0	0	**47**
Total	**249**	**167**	**379**	**239**	**74**	**16**	**0**	**875**

(Source: BRS)

Shuttle Tankers

- Generally they are conventional tankers equipped to be moored to a discharge buoy at deep sea
- Load their cargo directly from the oil field, where it is stored in reservoirs, where generally the sulphur is removed.
- Require a great maneuvering capability in comparison with the traditional tankers, and generally are equipped with dynamic positioning systems.
- Can be easily identified by the raised compartment at the bow and ramp to handle the cargo hose.
- Typically, a shuttle tanker as DW ~ 120,000 t and a service speed of abt. 16 knots, higher that conventional tankers.

Shuttle Tankers

"Viktor Titov", an Aframax tanker prepared for bow loading.

Product Tankers

- Carry refined oil products that can be classified into 2 main groups:
  - White products (Diesel oil, gasoline, jet fuels, kerosene, lube oils, etc.)
  - Black products (fuel oils, residual products)
- Clean cargo tanks characterized by:
  - No structural elements inside the cargo space (double skin)
  - Corrugated bulkheads (transverse and longitudinal)
  - Cargo tanks painted or internally coated
- Each cargo tank is provided with a segregated cargo system including a submersible pump and its own cargo line to the manifold, on deck
- The number of possible cargo segregations on board is equal to the number of cargo tanks
- Typically these tankers are smaller than the crude oil tankers, with DW < 70,000 t

Cargo Characteristics

Crude Oil

- **Crude Oil** – mineral oil composed by a mixture of hydrocarbons of natural origin, with variable density and viscosity

- **Heavy Crude Oil** – type of crude oil that exists in zones such as the Orinoco (Venezuela), the banks of Athabasca (Alberta/Canada) and the banks of Olenik (Siberia/Russia). They have the following characteristics:
  - Density close to or even higher than the water
  - High viscosity, can be almost solid at environment temperature
  - Can not be produced, carried and refined by the conventional methods
  - Generally they have high content of sulphur and some metals such as the nickel and the vanadium

Heavy Grade Oil

- In MARPOL Convention the designation of Heavy Grade Oil (HGO) is assigned to the following products:
  - Heavy fuels with density at 15°C > 900 kg/m3
  - Fuel Oils with
    - Density at 15°C > 900 kg/ m3, or
    - Kinematic viscosity at 50°C > 180 mm2/s
  - Bitumen, tar and its emulsions.

Crude Oil – Classification According to the Origin

- **Europe/North Sea** – light product, reduced viscosity, black.
- **West Africa** - more viscous than the one from North Europe, becomes more viscous at temperatures < 19 °C and volatizes quickly at temperatures > 27 °C.
- **South America** – heavy product, viscous
- **Persian Gulf**
- **Asia/China** – very heavy product.

Oil Products

- A large variety of products is obtained from the refined oil
- The oil products can be classified as:
  - ***White Products***
    - Gasoline
    - Petroleum
    - Jet-fuel
    - Gas oil
    - Aromatics
  - ***Black Products***
    - Diesel Oils
    - Fuel Oils
    - Asphalts

Some Definitions and Units

- **Barrel** (bbl) - Measure of capacity commonly used for crude and refined products. Its historical origin were the wooden barrels that were used to transport the first crudes extracted for commercial purposes.

  1 barrel = 35 imperial gallons = 42 US gallons = 159 liters.

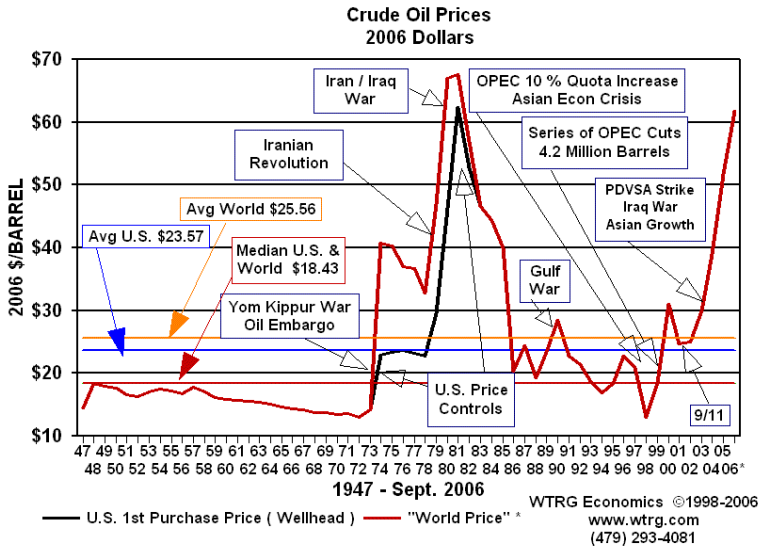
- **Specific Weight** - the standard temperature used by ASTM (*American Society for Testing Materials*) for the determination of the specific weight is 15.5° C (60° F).

- **API Grade** - scale adopted by the *American Petroleum Institute* to measure the oil density. The oils with a lower specific weight have higher API Grade.

  Calculated by the expression:

  API Grade = (141.5/Specific weight at 60° F) – 131.5

Evolution of the Crude Oil Prices (1947-2006)



17

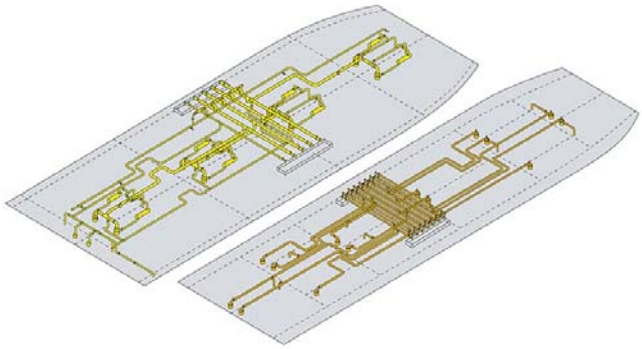
Systems for Cargo

Cargo Systems

- **Pump Room**
  - 1 pump for each cargo segregation (typically 3 or 4)
  - Centrifugal pumps of large capacity
  - The electrical driving engines are located in the Engine Room

- **Submersible Pumps**
  - 1 pump for each cargo tank
  - 1 portable pump
  - Piping system entirely above the main deck

Arrangement of the Cross-Over



- Refer to "Recommendations for Oil Tanker Manifolds and Associated Equipment", OCIMF.

Other Cargo Systems (1)

Bow Loading System (BLS)

- Used in *shuttle-tankers* to receive the crude oil from cargo terminals, from cargo buoys and from FPSO's and FSU's.

The shape of the bow of these ships must be adapted to the installation of these systems.

Other Cargo Systems (2)

Stern Discharge System (SDS)

- Installed aft in FSU's and FPSO's to discharge the cargo to shuttle-tankers.
- The system is supplied with a storage drum for the discharge hose or, in alternative, with horizontal storage of the hose in a conveyor

Stern Loading and Discharge System (SLDS)

- Results from the development of BLS and SDS which allow a ship to load/discharge cargo through the bow extremity.
- It is an attractive alternative from the economical point of view for the multi-purpose ships.

Other Cargo Systems (3)

Submerged Turret Loading (STL)

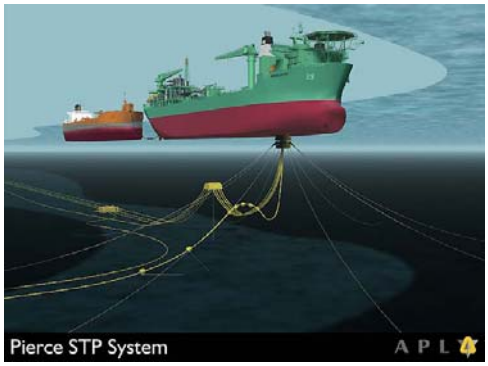
- Technology for *offshore* load of crude oil.
- With the STL system the loading operations can be carried out in worse sea states then with the previous systems.

- The STL Buoy moored by a cable is lifted to a recess in the ship's bottom and allows the effective mooring of the ship
- The STL Buoy is composed by a tower and a system that allows the free rotation (*swivel*) of the ship due to the atmospheric conditions.

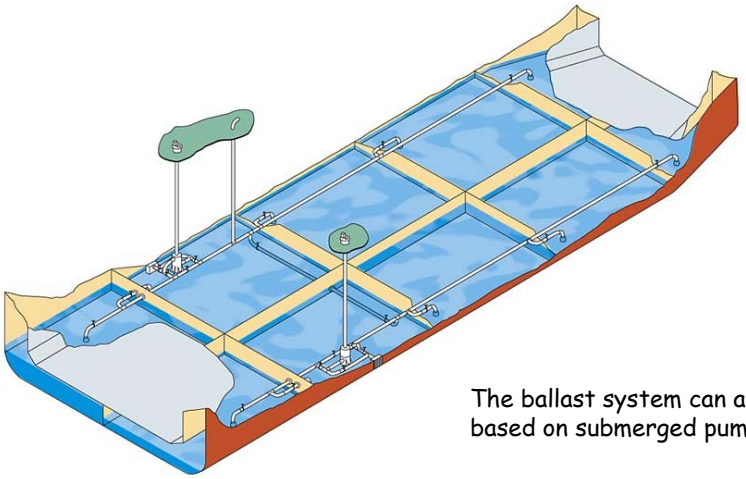
Systems for Cargo

Submerged Turret Production (STP)

- Innovative concept for FPSO's that uses STL technology together with a high-pressure multiple way system, disconnectable, supplied by Framo Engineering.



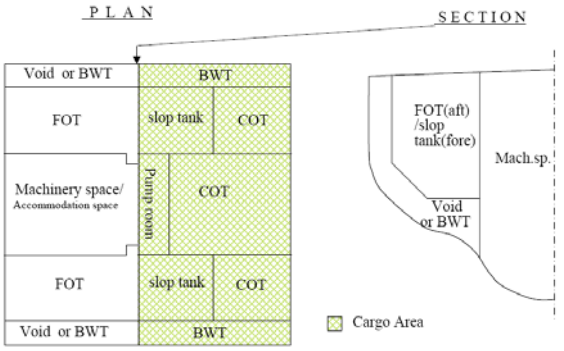
Ballast Systems



The ballast system can also be based on submerged pumps.

SOLAS

Protection of the Fuel Oil Tanks

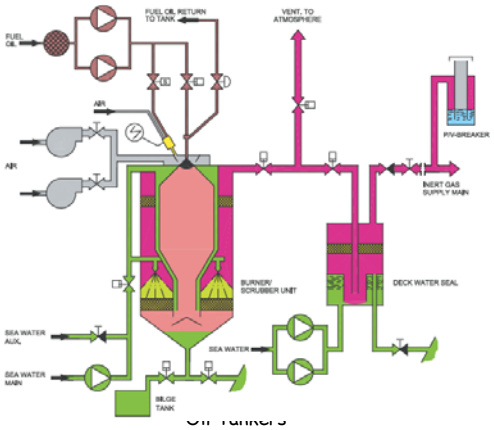


Void space or ballast water tank protecting fuel oil tank as shown in Figure, need not be considered as "cargo area" defined in Reg. II-2/3.6 even though they have a cruciform contact with the cargo oil tank or slop tank.

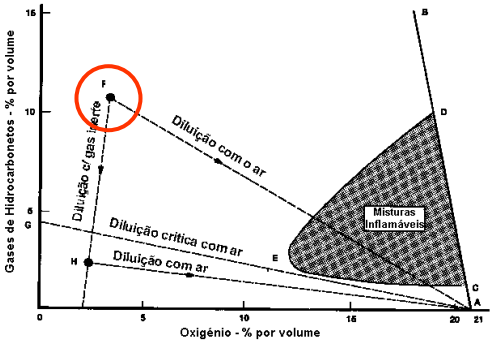
The void space protecting fuel oil tank is not considered as a cofferdam specified in Reg. II-2/4.5.1.1. There is no objection to the locations of the void space shown in the Figure, even though they have a cruciform contact with the slop tank.

Inert Gas System (IGS)

- The system can be fed by the exhaust gases, by an inert gas generator or by nitrogen.



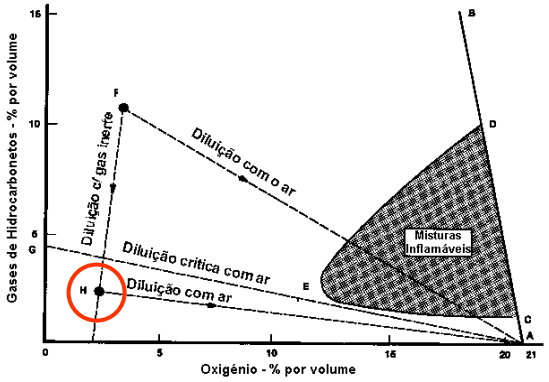
Mixture Diagram Hydrocarbons/Air/Inert Gas



- Point A corresponds to the breathing air (~20,8% Oxygen).
- The gray zone is the dangerous one, starting at about 11% oxygen
- Normally on board it is used a safety margin, working with 5% - 8%.

For example, if the discharge is at point F, and if this atmosphere is open to the outside there would be a mixture with the air (oxygen) following the line FA which is not advisable, because it would pass through the dangerous zone.

Mixture Diagram Hydrocarbons/Air/Inert Gas



- The typical procedure is to introduce inert gas until the point H, and then there is no more concern with the oxygen because the mixture follows the line HA.

Cargo Tank Venting System

- SOLAS Chap.II-2 Regulations 59 e 62

Cargo Tank Venting System

- On 1st July of 1998 it became a SOLAS requirement that the tankers are equipped with a secondary mean to avoid over/under pressure in the tanks in the eventuality of the failure of the main pressure/vacuum (p/v) system.
- Also required are devices that guarantee that the valves are opened before any loading or ballasting operation.

Crude Oil Washing System (COW)

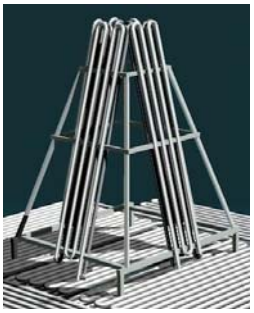
- Rotative washing machines

Cargo Heating System (1)

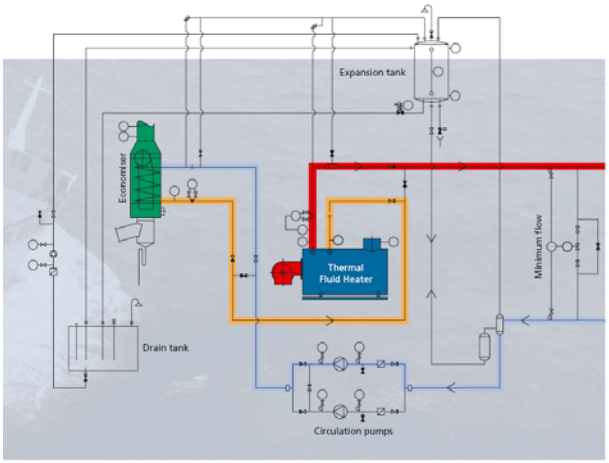
- The cargo tanks and the *slop tanks* are equipped with a cargo heating system
- The purpose of the system is to heat the crude up to a temperature at which the viscosity will allow it to handled by the cargo pumping system

Cargo Heating System (2)

- The heating can be obtained from the circulation of steam or a thermal fluid (Ex. Mixture of water and glycol) in a system of heating coils
- The heating coils can be in aluminum bronze or in stainless steel
- Max. cargo temperature: 65°C



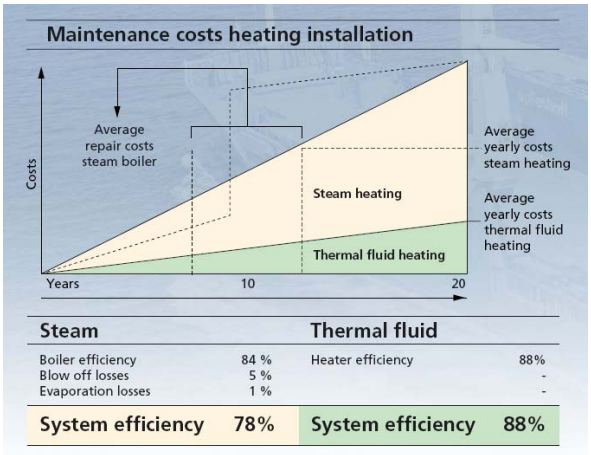
Cargo Heating by Thermal Fluid



Fluid composed by mineral or synthetic oils

Typical Diagram of the Cargo Heating System

Comparison of Maintenance Costs of Types Heating Systems



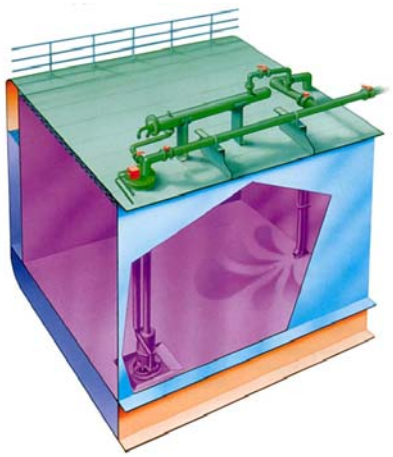
Steam		Thermal fluid	
Boiler efficiency	84 %	Heater efficiency	88%
Blow off losses	5 %		-
Evaporation losses	1 %		-
System efficiency	**78%**	**System efficiency**	**88%**

The systems based on thermal fluid present higher efficiency values in comparison with the traditional steam ones

Fonte: Aalborg

Cargo Heating System (3)

- In alternative the heating can be obtained by a system without heating coils, based on the recirculation of the cargo by submerged pumps through heat exchangers mounted on deck
- Advantages:
  - The absence of heating coils facilitates the tank washing
  - The heat exchangers are not exposed to the cargo when the cargo is not beeing heated (less corrosion)



Foam System for Fire Extinguishing (1)

Foam Monitors

- The foam supply rate shall be not less than the larger of the following values:
  - 0.6 liter/min./m2 of the protected area of the cargo tank, computed as the product of the maximum breadth by the length of the cargo zone
  - 6 liter/min./m2 of the maximum horizontal section of an individual tank
  - 3 liter/min./m2 of the area protected by the largest monitor, entirely forward of it, but not less than 1250 l/min.

Foam System for Fire Extinguishing (2)

- The distance from the foam monitor to the extreme point of the protected area shall not be > 75% of the monitor ranger
- Forward of the poop deck or of the superstructure, 2 foam monitors shall be installed, one at each side, oriented to the cargo area.

Deluge System for Fire Extinguishing

- System developed by BP Shipping, after the accident on the M/V "British Trent", where after a collision, there was a break on the fire manifold and, when launching the lifeboatas, these become covered with oil on fire and there were 10 casualties.
- The objective is to produce a water curtain around the mustering stations, allowing the lifeboats to be launched safely.
- Spray nozzles are fed from the fire manifold and create a water curtain which protects the lifeboat from top, forward and side.
- The system is operated manually from the Fire Control Room after the order to abandon ship.
- Due to the demands of this system, sometimes an additional pump must be installed.

Emergency Towing Arrangement (ETA)

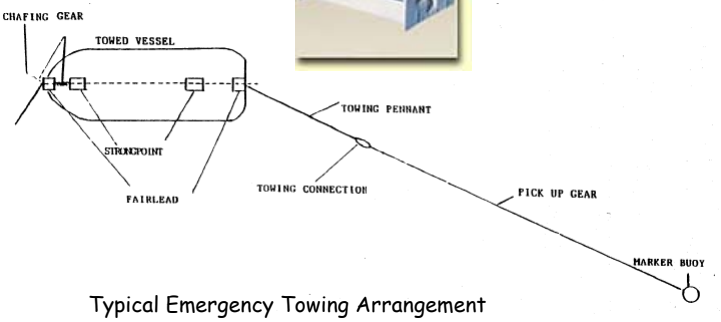
- Required by SOLAS in oil tankers, product tankers, chemical tankers and LPG/LNG with DW > 20,000 t
- Installed forward and aft
- Refer to IMO MSC.35(63) "Guideline for Emergency Towing Arrangement on Tanker", with alterations from MSC 132(75)
- Regulation V/15-1, amendments 1994 to SOLAS.

Emergency Towing Arrangement (ETA)

- Has the purpose to facilitate the salvage of tankers after an eventual accident
- The components required are on the table:

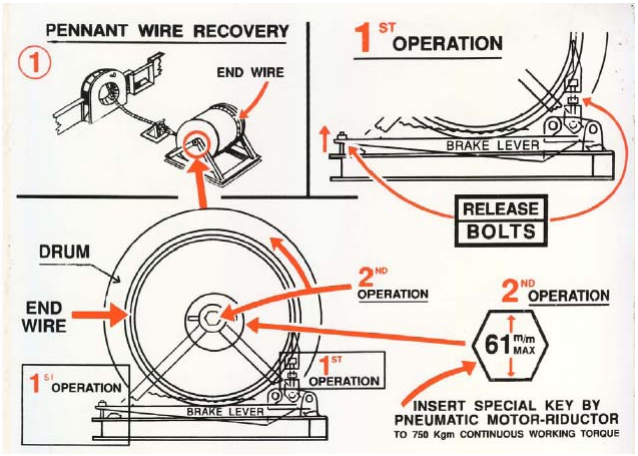
	Forward	Aft	Resistance Requirements
Pick-up gear	Optional	Yes	--
Towing pennant	Optional	Yes	Yes
Chafing gear	Yes	Depends from the design	Yes
Fairlead	Yes	Yes	Yes
Strong point	Yes	Yes	Yes
Roller pedestal	Yes	Depends from the design	--

Emergency Towing Arrangement (ETA)

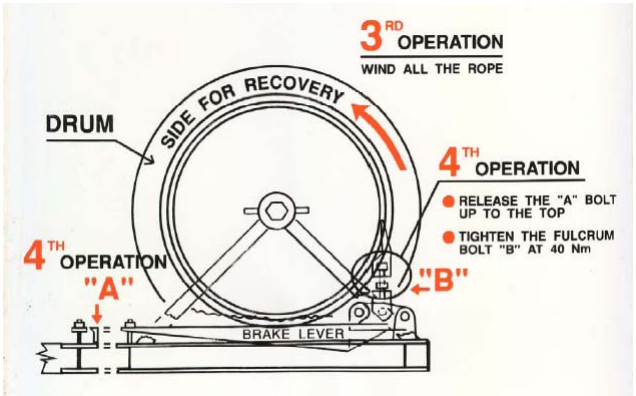


Typical Emergency Towing Arrangement

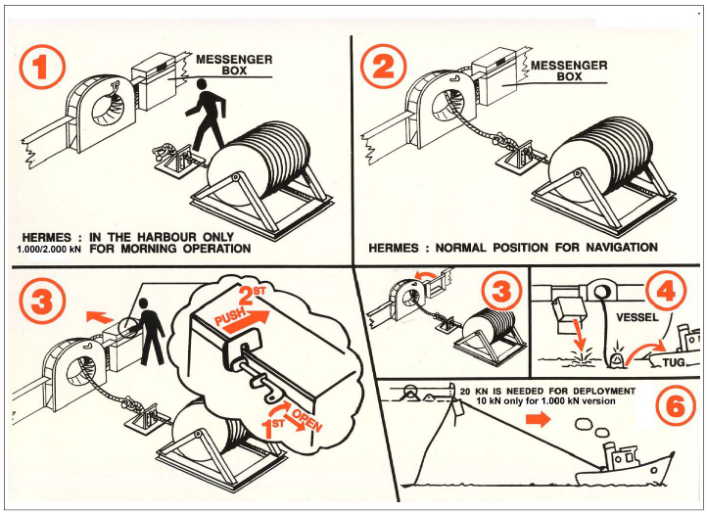
ETA - Operation



ETA - Operation



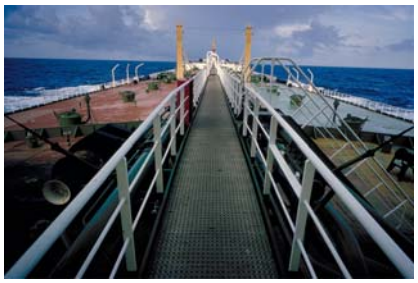
ETA (Installed Aft) - Operation



Safe Bow Access in Tankers (1)

- All tankers built after 1st July 1998 shall have the necessary means to allow the crew to access the bow, even in severe weather conditions.
- The access is required to allow the crew to release the anchors, install or adjust towing equipment, and reach the lifesaving equipment in case of emergency.
- The access shall be done through
  - an access path on deck, or
  - a raised platform, of permanent construction, with substantial strength, located at the level of the superstructure deck or of 1st pavement of a deckouse, or above

Safe Bow Access in Tankers (2)



Raised platform for bow access

Safe Bow Access in Tankers (3)

A raised platform shall:

1. Have a width ≥ 1 m, positioned above or as close as possible to the centerline plan of the ship and located in such a way that it does not interfere with the easy access through the work areas on deck

2. Be equipped along its entire length with foot stop and handrails supported by pillars.
   - The handrails shall have at least 3 levels, the lower of which shall not be at more than 230 mm and the upper one at least 1 m above the deck
   - Shall not have intervals with more than 380 mm height
   - The pillars shall have a spacing ≤ 1.5 m.

Safe Bow Access in Tankers (4)

3. To be built with fire resistant and anti-skid material

4. To have openings with ladders to the deck, where appropriated. The openings shall have a spacing less than 40 m

5. If the length of the exposed deck exceeds 70 m, it shall have shelters with intervals less than 45 m. Each of these shelters shall be capable to at housing least one person and be built to provide protection against the weather, forward, portside and starboard

6. If obstructed by piping or other permanent elements, it shall be provided with means to overpass it.

Refer to "Guidelines for Safe Access to Tanker Bows", IMO Maritime Safety Committee resolution MSC.62(67).

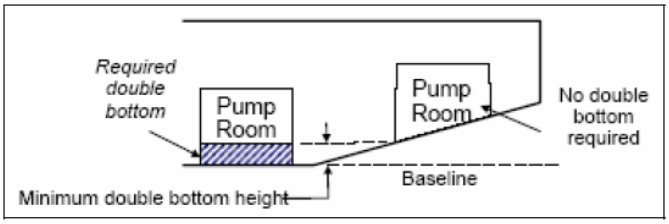
MARPOL

Protection of Pump Room Double-Bottom

- SOLAS Regulation 22
- Tankers with DW ≥ 5,000 t shall have a double-bottom in the pump room zone, with a height above the base line ≥ MAX(B/5, 2.0 m)
- The double-bottom space can be used as a void, ballast tank or fuel oil tank (if it does not violate other rules, namely the Rule 17A)
- Ballast piping can be located in the double-bottom of the pump room if any damage in those pipes does not make the pumps inefficient
- Refer to IACS

Protection of Pump Room Double-Bottom

- The Pump Rooms in ships with a gondola stern shape do not need to be provided with a double-bottom where the distance from the bottom plate to the base line is larger than the minimum height of the double-bottom



Oil Discharges

Within special areas OR outside special areas, within 50 nautical miles (nm) from the nearest land	ANY DISCHARGES IS PROHIBITED, except clean or segregated ballast
Outside special areas, more than 50 nm from the nearest land	ANY DISCHARGE IS PROHIBITED, except clean or segregated ballast, or when: 1. the tanker is proceeding en route, and 2. the instantaneous rate of discharge of oil does not exceed 30 litres/nm, and 3. the total quantity of oil discharged into the sea does not exceed - 1/15,000 (for existing tankers) and/ - 1/30,000 (for new tankers) of the total quantity of the cargo which was carried on the previous voyage, and 4. the tanker has in operation a monitoring and control system for the discharge of oil, and slop tank arrangements as required by Regulation 15.

In tankers of every dimensions, it is required the control of discharge from the tanks areas, including the pump room

Other Systems and Equipments

Platform for Helicopters Landing (1)

Reference Documents:

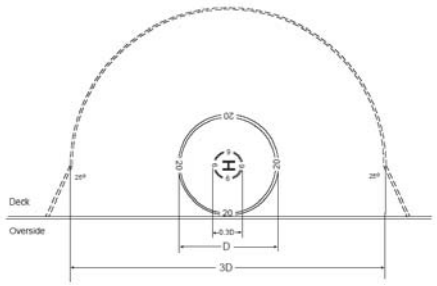
- "Guide to Helicopter/Ship Operations", International Chamber of Shipping, 3rd Edition, 1989, London.
- MODU (*Mobile Offshore Drilling Units*) Regulations
- ✓ DNV (2008), "Helicopter Decks", Offshore Standard DNV-OS-E401

Types of Helicopter Landing areas

- Zone amidships
- Zone at side
- Zone aft of the superstructure

Platform for Helicopters Landing (2)

D = rotor diameter



Landing Zone at side (more common in tankers):

- Circle of continuous line, white or yellow, with a minimum width 0.01D, interrupted with intervals of 90° with numbers indicating the diameter.
- Center marked with the uppercase character H, white or yellow (0.2D x 0.1D) draw with lines of 0.02D width.

Platform for Helicopters Landing (2)

- The diameter <D> of the helicopter deck or landing area for single main rotor helicopters shall not be less than the overall length of the helicopter, including main and tail rotors running.

Table A1 D-value for typical helicopters

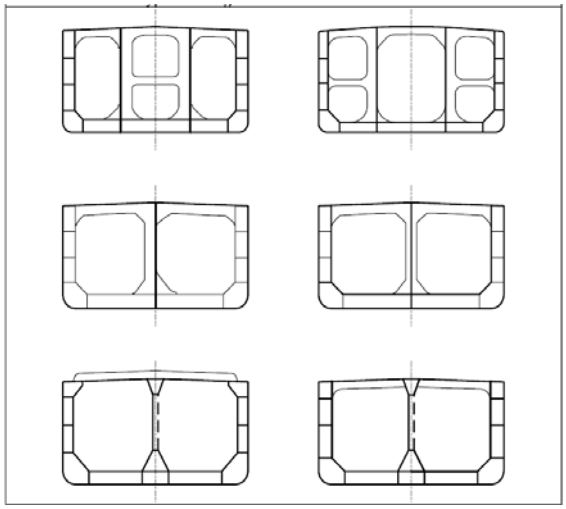
Type	*D-value (m)*	*Rotor diameter (m)*	*Maximum weight (kg)*
Bolkow Bo 105D	12.00	9.90	2400
Bolkow 117	13.00	11.00	3200
Agusta A109	13.05	11.00	2600
Dauphin SA 365N2	13.68	11.93	4250
Sikorsky S76 B & C	16.00	13.40	5307
Bell 212	17.46	14.63	5080
Super Puma AS332L	18.70	15.00	8599
Bell 214ST	18.95	15.85	7936
Super Puma AS332L2	19.50	16.20	9150
Sikorsky S61N	22.20	18.90	9298
EH101	22.80	18.60	14600
Boeing BV234LR Chinook	30.18	18.29	21315

Annex A. IACS Common Structural Rules for Double Hull Tankers

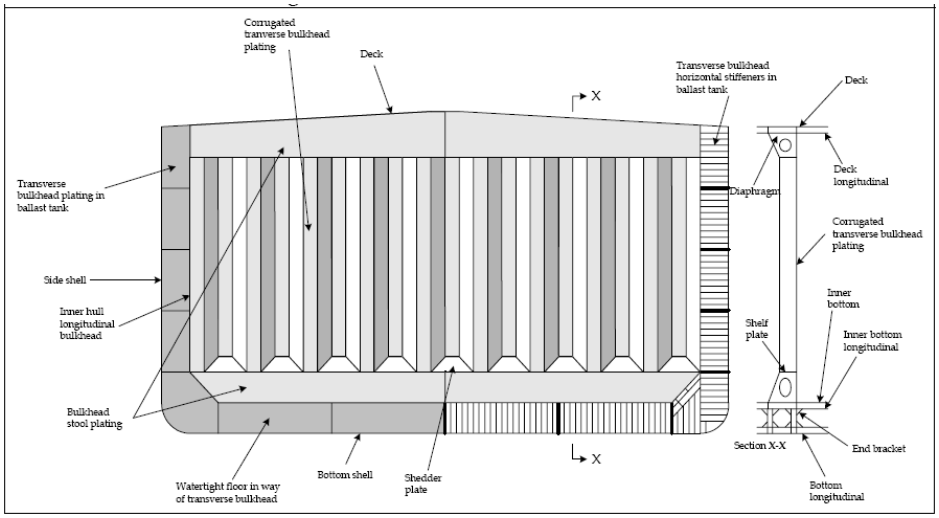
IACS Joint Tanker Project (JTP)

- LRS, ABS e DNV
- Set of Rules about the structure of double-hull oil tankers
- Length ≥ 150 m
- Entry into force: 1st January 2006

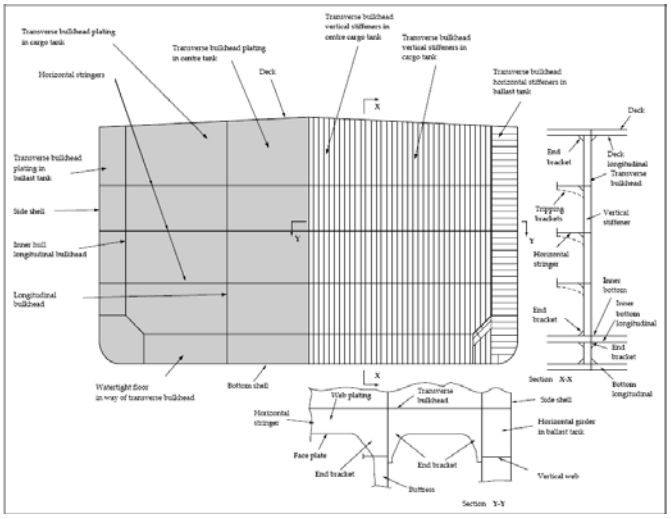
Typical Bulkhead Arrangements in Tankers



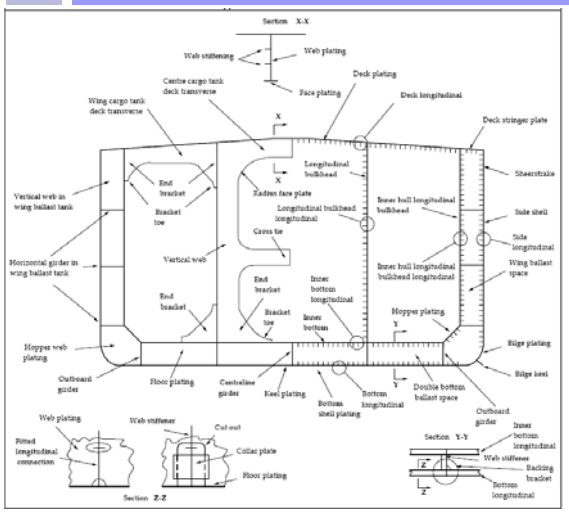
Typical Corrugated Bulkhead



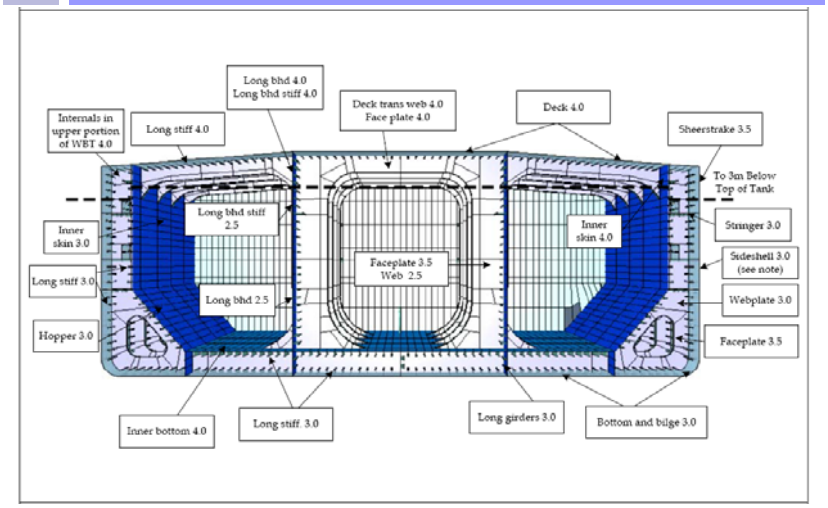
Typical Planar Bulkhead



Midship Section



Corrosion Allowances



Material Safety Data Sheets (MSDS)

- Material Safety Data Sheets must be onboard of:
  - All tank ships subject to the SOLAS Convention carrying Annex I cargoes
  - All ships using Annex I marine fuels
- These MSDS must be for each type of Annex I cargoes or Annex I marine fuels onboard
- This SOLAS requirement will become effective January 1, 2011.
- Check <www.regulations.gov> for the data sheets format suggested by the US Coast Guard (CD-ROM#64)

Annex B. International Association of Independent Tanker Owners

INTERTANKO

INTERTANKO

- Created on 1970
- Aimed at independent owners and operators of oil and chemical tankers
- It has about 250 members, with a fleet of more than 2,960 ships, corresponding to about 160,000,000 DWT

Annex C. Oil Companies International Maritime Forum

OCIMF

Oil Companies International Maritime Forum

- www.ocimf.com
- Organization created in 1970, in the following of the "Torrey Canyon" accident
- The objective is to promote safety in operation of oil tankers and terminals, through the improvement of design and operation standards
- In 2006 the number members was 56
- Publishes a regular newsletter regular and several types of safety standards

International Tanker Safety Guide for Oil Tankers and Terminals (ISGOTT)

- Published by OCIMF
- Summary of the Document (5ª Edition)
  - General Information
  - Tanker Information
  - Terminal Information
  - Management of the Tanker and Terminal Interface

Annex D. Oil Tankers

"Jahre Viking" – The Largest Oil Tanker Built

Lpp = 458.0 m
B = 69.0 m
DW = 564,763 t
Construção: 1979
Estaleiro: SUMITOMO, Japão

Currently the "Knock Nevis" (Norway) was adapted to floating storage (FSO), in Qatar
It is still the larges ship in the world.

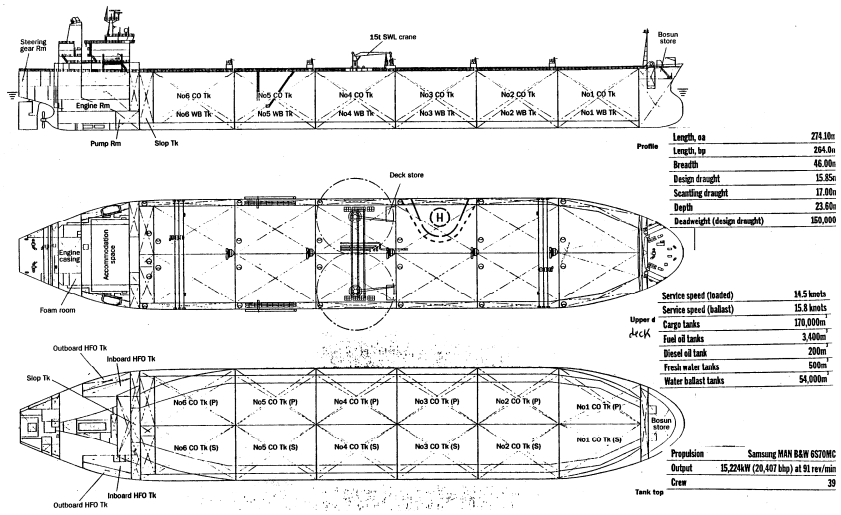
Beginning of the 1990s – European Shipyards bet on Double-Hull Oil Tankers

1st Double-Hull VLCC

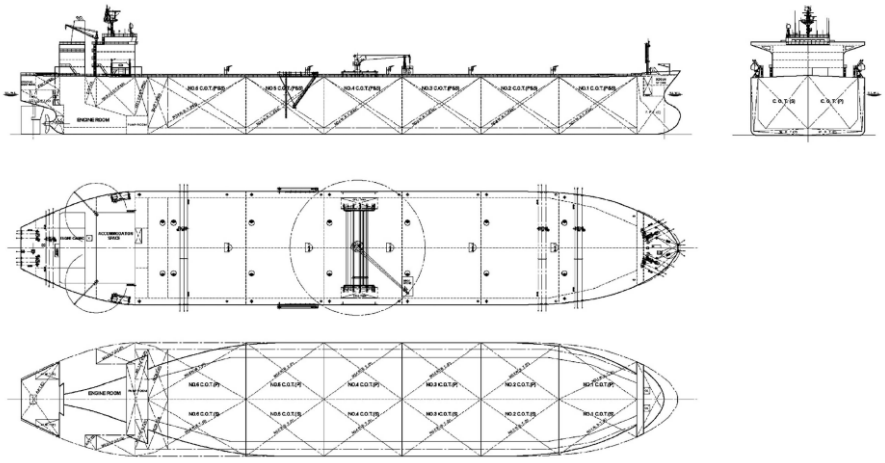
M/T 'Eleo Maersk' built in Odense SS in 1993

- In the sequence of the 'EXXON VALDEZ' accident, the European shipyards started several double-hull projects:
  - Project E3 developed by Fincantieri, Chantiers de l'Atlantique, HDW, Bremer Vulkan and Astilleros Españoles
  - DH VLCC's from Odense
  - DH Suezmaxes from Harland & Wolff, Fincantieri and Astilleros Españoles
  - DH Aframaxes and Shuttle tankers from Masa Yards, Fincantieri and Astilleros Españoles
  - DH Panamaxes from Burmeister & Wain, etc..

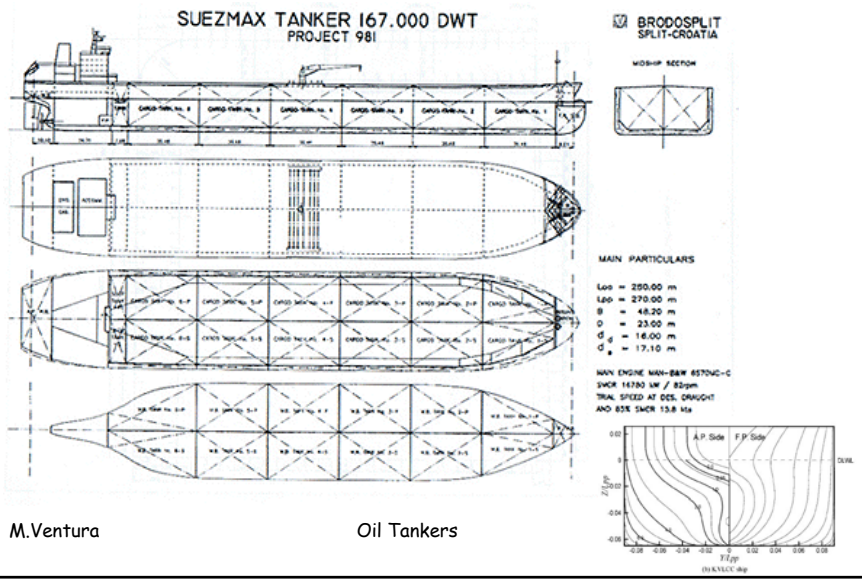
Oil Tanker



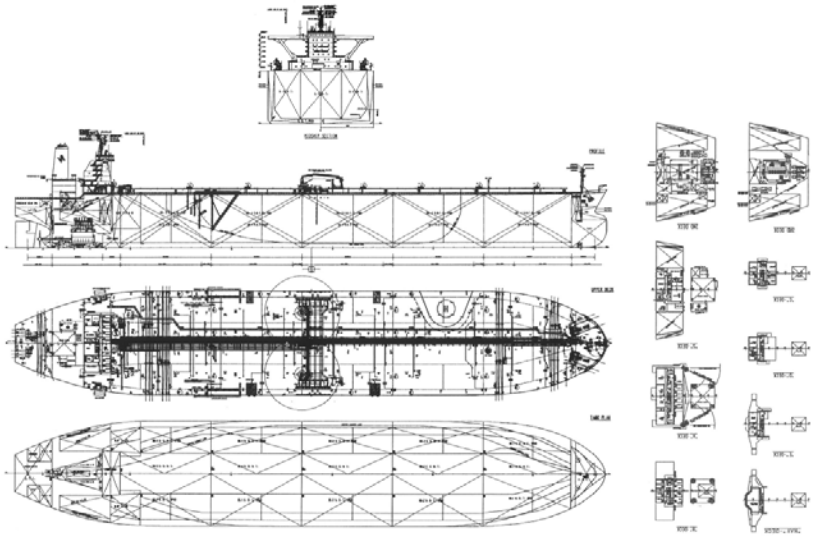
Minerva Lisa (105,000 DWT)



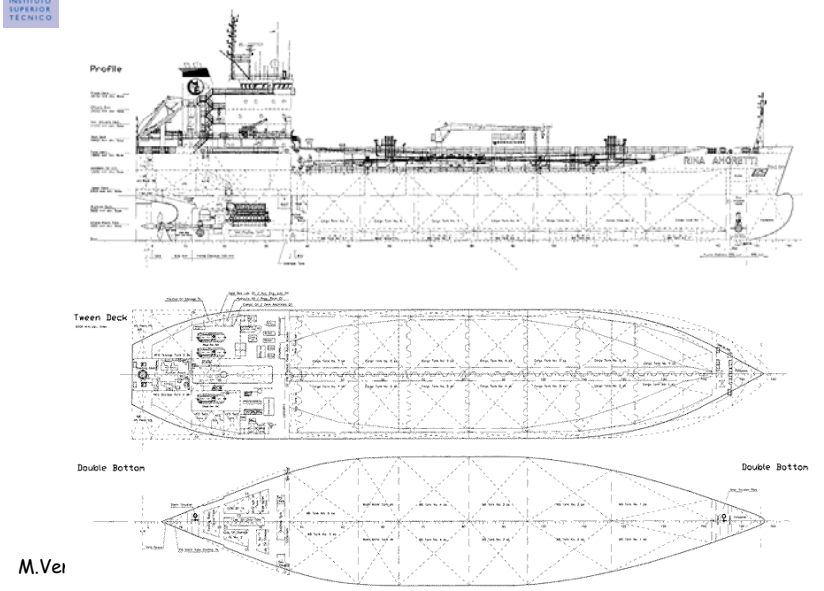
SuezMax Tanker



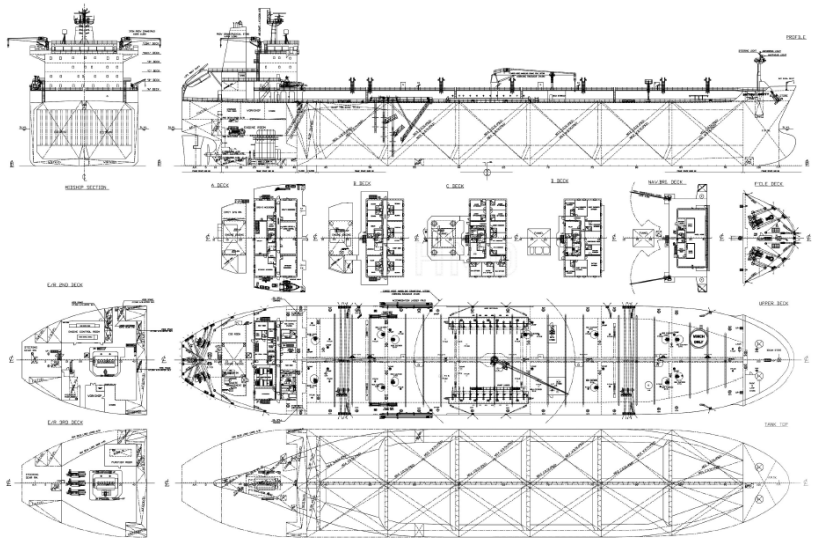
IRENE SL (VLCC)



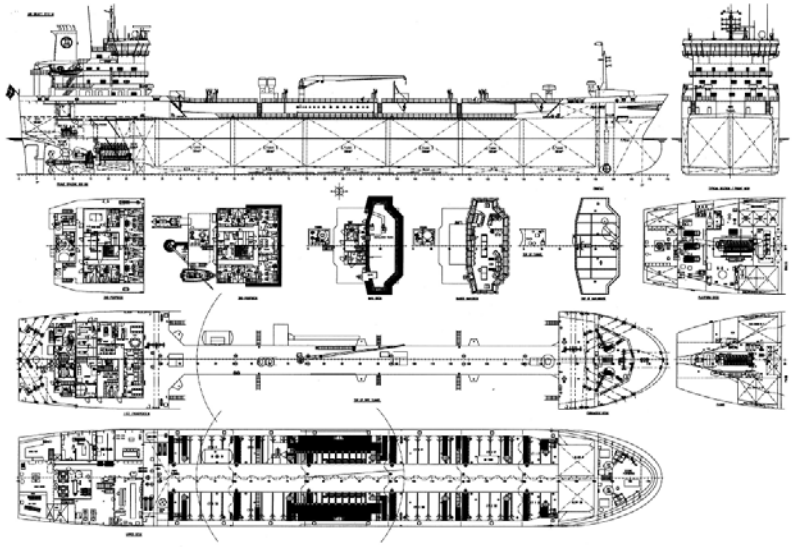
Product Tanker



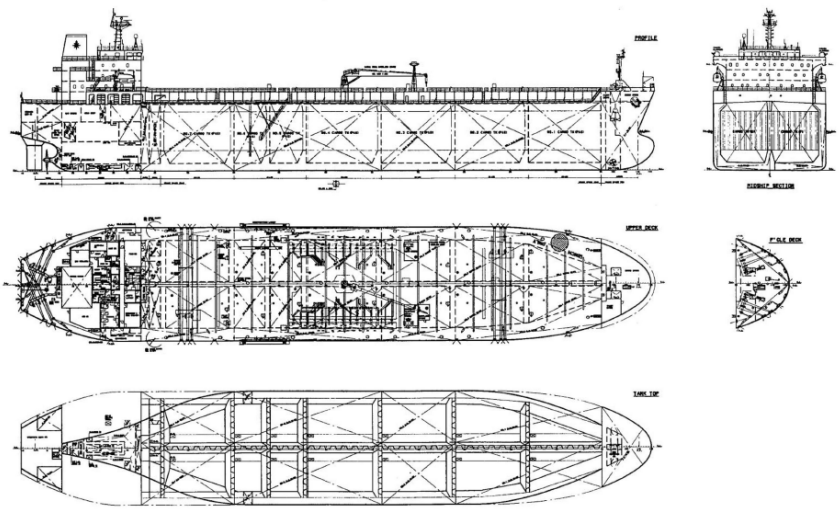
British Liberty – Product Tanker



Fure Nord – Product Tanker



High Endeavour – Product Tanker



Tempera (Double Acting Tanker)

Normal Mode

Tempera
Sumitomo Heavy Industries (Japão)
5 x Wartsila
Propulsion Azipod, 16,000 kW
V = 17' (V = 3' in ice)

Ice-breaking Mode

Links

- www.bp.com (British Petroleum)
- www.tankeroperator.com (Tanker Operator Magazine)
- www.teekay.com (Teekay Corporation)
- www.uptankers.com (United Product Tankers)
- supertankers.topcities.com