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# Ships auxiliary machinery

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# Ships auxiliary machinery

- In passenger vessel roughly
  - 21 HVAC systems
  - 8 machinery systems
  - 16 auxiliary systems
- This lecture includes ”selected systems”
  - Run the engine (make electricity)
  - Heat the vessel
  - Bilge systems
  - Fire main
  - Ballast system
  - Short descriptions abt. HVAC systems

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# Ships auxiliary machinery

- Major sources:
  - Wärtsilä 32 product guide:
    https://www.wartsila.com/marine/products/engines-and-generating-sets/diesel-engines/wartsila-32

    Alfa-Lavall WWW-pages:
    https://www.alfalaval.fi/teollisuusalat/meriteollisuus-ja-kuljetusala/meriteollisuus/
  - Pentti Häkkinen, Laivan koneistot, 1993
  - Pentti Häkkinen, Laivan putkistot, 1994
  - NB 506, 515 and 516 design materials (only in presentation)
    - As-built diagrams of Helsinki shipyard delivered vessel

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# Fuel oil (MDO) system

- MDO(F) configuration
- Double feed pumps (Screw type)
- Fuel cooler in return line
- Flow meter(s)
  - Needed also on return line
- “Diesel generators serving as main source of electrical power must be able to resume their operation in black out situation”
  - Gravity tank (15 m) or black out pump (air driven) needed
- Engines leak fuel..

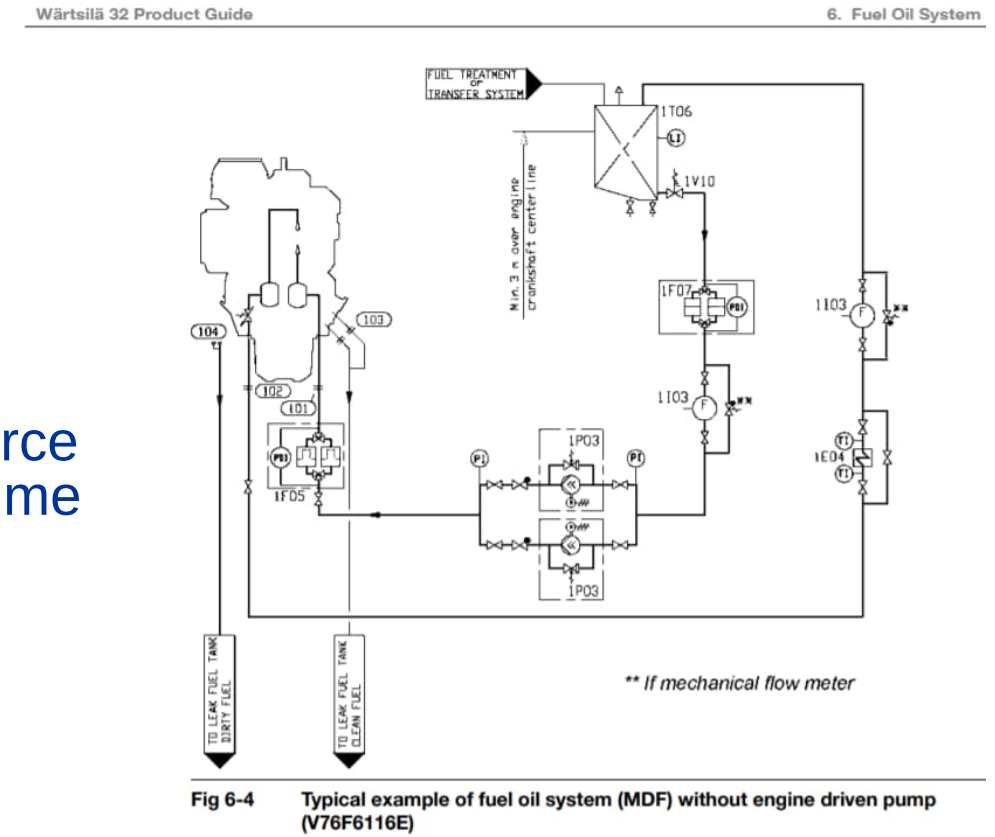


Fig 6-4 Typical example of fuel oil system (MDF) without engine driven pump (V76F6116E)

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# Fuel oil (HFO) system

- HFO configuration
- Double feed pumps (Screw type)
- Automatic filter for fuel
- De aeration tank
- Double circulation pumps (Screw type)
- Fuel heaters
- Viscosity meter in feed line (Control heating)
- MDO system needed for overhauls and black out recovery
- Pipes (HFO) insulated and trace heated
- Flow meter in feed line
- Engines leak fuel.. (Leak pipes to be insulated and trace heated)



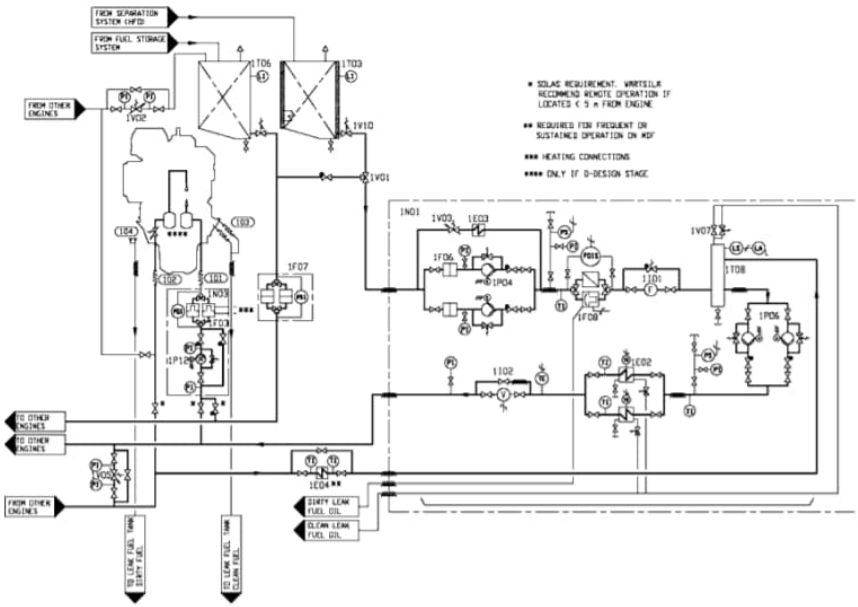

Fig 6-6 Example of fuel oil system (HFO) multiple engine installation (V76F6628F)

# Lub oil system

- “Dry Sump” engine
- External system oil tank
- Engine driven pumps
  - El driven pre-lub pump built in
- Stand-by pump needed if only prime mover
- Lub oil separator, with heater
  - Less use in non HFO vessels
  - Sludge tank
- Oil cooler in LT-cooling circuit

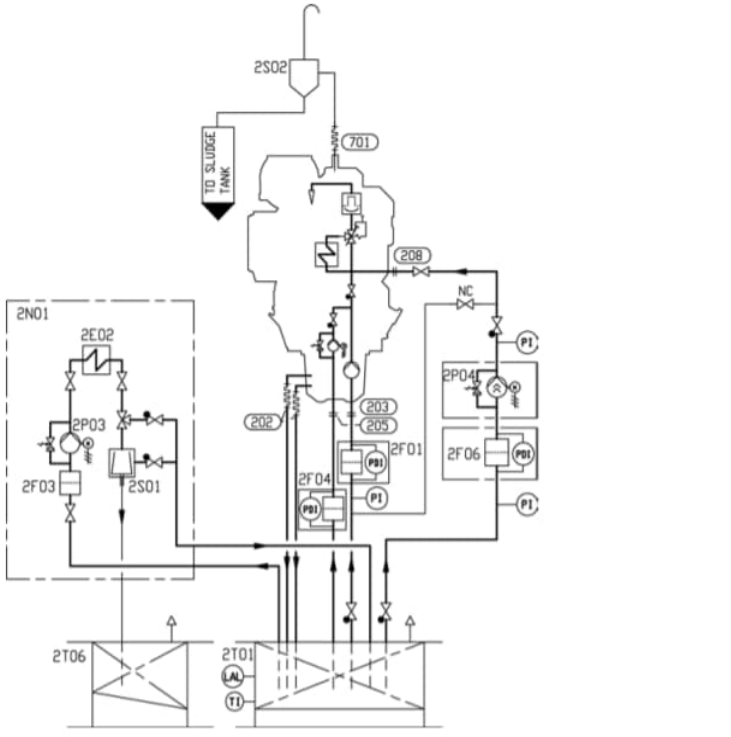


Fig 7-1 Lubricating oil system, main engines (V76E4562D)

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# Cooling water system

- Sea water system
  - 2 centrifugal pumps (2x50%)
  - 2 plate coolers (Titanium plates 2x50%)
  - Vessels for cold waters 3-way valve to control return flow (heating of sea water)
  - -2°C – 32°C (Specification issue)
- Combined LT/HT cooling
  - Engine driven pumps
  - HT preheating
  - Evaporator in HT circuit (Fresh water maker)
  - El driven stand-by pumps (single engine installation)
  - Fresh water with additives
  - LT ~36°C, HT~85°C

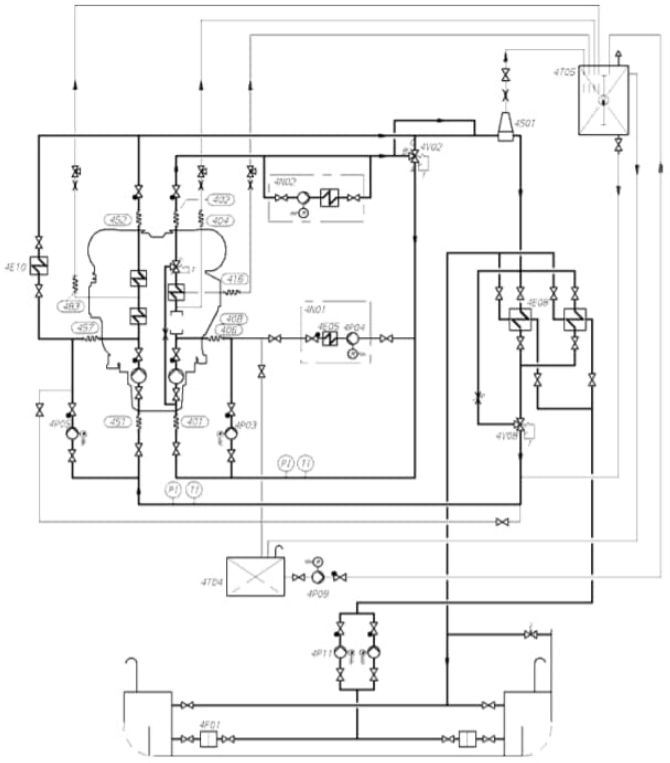

Fig 9-1 Example diagram for single main engine (MDF) (3V76C5775C)

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# Starting air system

- Double starting air compressors (typically piston type)
  - Cooler and water separator in compressor
- Pressure 30 bar (test pressure 45 bar)
- Double air vessels
  - Dimensioning acc class (typically for 12 starts for 1 engine)
- Filter prior engine (air fed to cylinder via starting air valve)
- Engines needs also control air
- Typical new engines needs “air assist” for fast power ramps of power in low loads
  - big air consumption

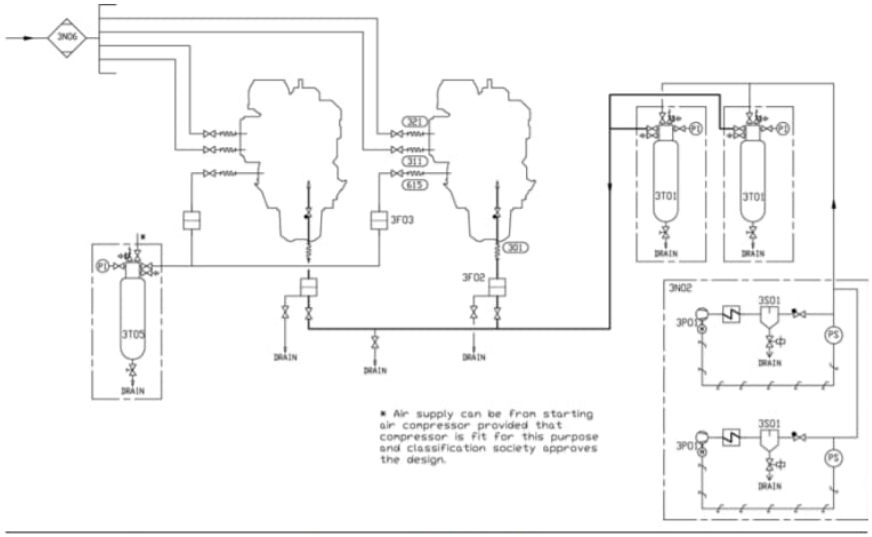


Fig 8-1 External starting air system (3V76H4142F)

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# Exhaust gas system

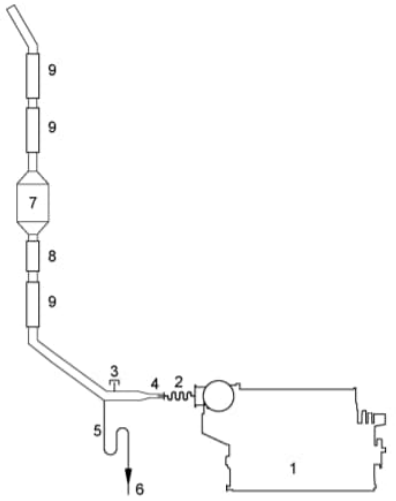
- SCR catalysators industry standard in medium speed engines
  - High efficiency engines leads to NOx
  - NOx reduction -> SCR
  - Urea feed pipes and equipment
  - Urea tank
- Typically 1 silencer per engine
- Exhaust gas boiler “top of” SCR (if installed)
- Water trap needed, drain always open
- Exhaust gas pipe supporting and bellows need careful design



## External exhaust gas system

Each engine should have its own exhaust pipe into open air. Backpressure, thermal expansion and supporting are some of the decisive design factors.

Flexible bellows must be installed directly on the turbocharger outlet, to compensate for thermal expansion and prevent damages to the turbocharger due to vibrations.




1 Diesel engine
2 Exhaust gas bellows
3 Connection for measurement of back pressure
4 Transition piece
5 Drain with water trap, continuously open
6 Bilge
7 SCR
8 Urea injection unit (SCR)
9 CSS silencer element

**Fig 11-4 External exhaust gas system**

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# Exhaust gas pipes and combustion air in passenger vessel

- Silencers and SCR are big
- Vessel should not emit noise or visual smoke
- Engine casing used as return channel for ventilation
- Two casings, redundancy (SRTP)
- Combustion air needs also space.
- Typically combustion air is taken from ER

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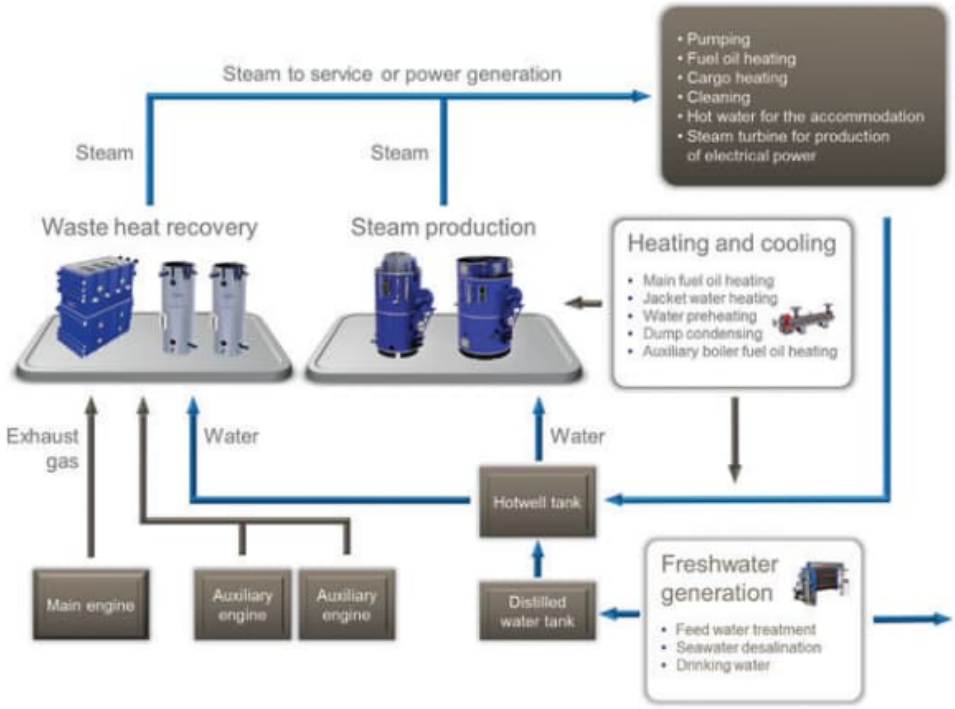
# Steam/heat generation (Boilers)

- Heating:
  - Fuel oil feed and fuel tanks
  - Trace heating (HFO)
  - Ballast tanks (cold climate vessels)
  - Potable water (hot water)
  - Fresh water generation (Evaporators)
  - Pre-heating of engines
  - Pre-heating and re-heating of AC
- Oil fired boilers, heating media:
  - Steam (aux systems typical 8 bar, 145°C)
  - Thermal oil (max 300°C, typical 180°C)
  - Hot water (typical below boiling point ~85°C)
- Exhaust gas boilers
  - Used in combination with steam boilers (Water and thermal oil EGB rare)
  - Uses heat from exhaust gases
  - Considered as free heat, but needs maintenance and pumping power
- Electrical boilers
  - Used in parallel with waste heat recovery from HT
  - Potable water boiler, typically for balancing the heat load
- Boiler type is selected according vessels needs
  - MDO/HFO – Temperature and trace heating
  - Energy need, de-icing, temperatures, tank heating, tank washing, cargo heating

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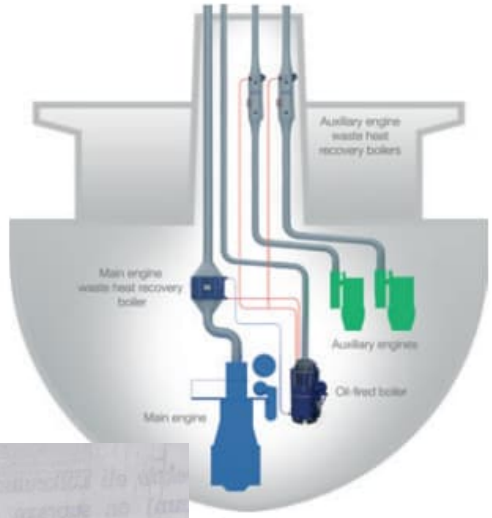
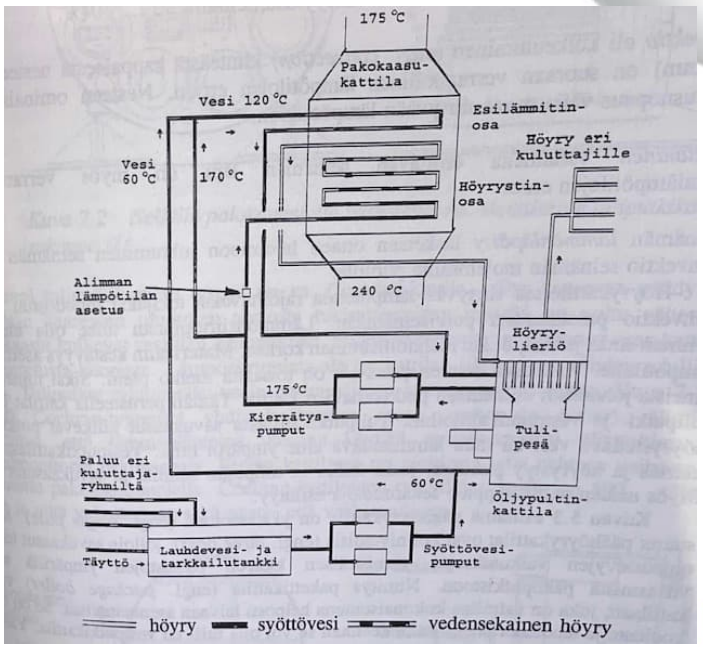
# Typical steam boiler plant

- The steam drum is typically on top of the boiler
- Feed water is pre-heated in exhaust gas boilers
- The temperature control of exhaust gases are important due corrosion of exhaust gas pipes (Sulphur tri-okside)
- Feed pumps for boilers are doubled
- Plant is dimensioned to fulfill needs of the vessel Heat balance calculation

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# Heat balance

- Calculated or estimated by experience (database) heat loads listed
- Load factors for different operating modes defined
- Heating needs for different modes calculated
- If vessel have exhaust gas boilers the production would be evaluated according exhaust gas mass flow and temperature and boiler characteristics
- Selection of aux boilers accordingly

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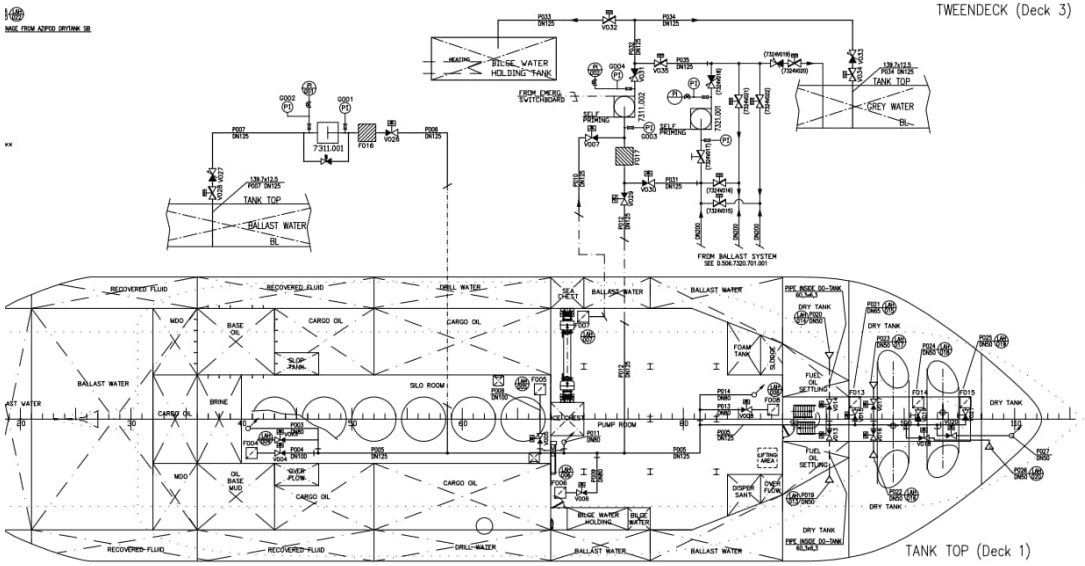
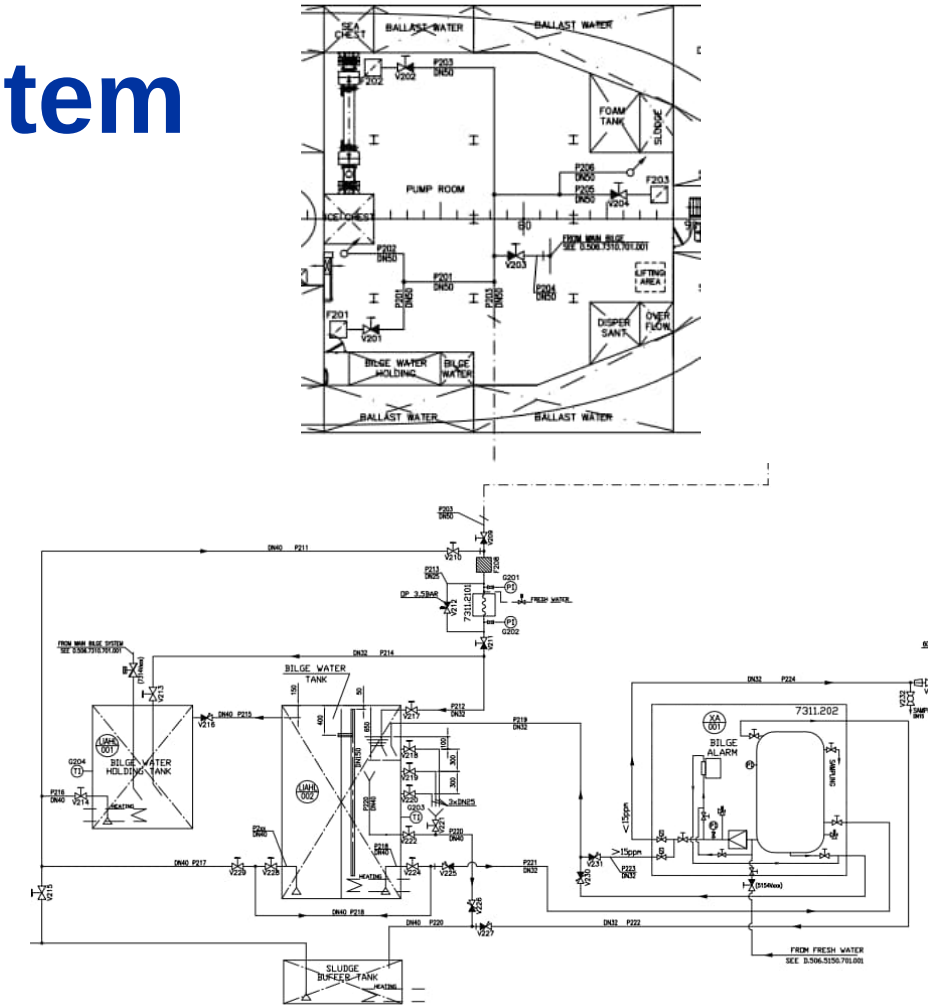
# Main bilge

- Pumps:
  - Min 2 pcs for cargo and 3 for passenger vessel
  - Self priming (water ring, screw, or piston) or automatically primed (automatical ejector)
  - One piston pump or other pump naturally generating vacuum (Screw type)
- Emergency pump for engine room
  - Biggest water pump to have suction from bilge and possibility to pump straight to sea
  - Usually sea water cooling pump
- Suction from all spaces (having possibility to get sea water)
  - Definitions can be found in SOLAS and Class rules
  - Tanks having own system for filling and emptying not included (Ex. Ballast and Fuel tanks)
- Piping:
  - Non combustible (Steel, usually galvanized)
  - Sizing and wall thickness regulated by Solas



# Daily (oily) bilge system

- System to drain oily bilge water:
  - From engine spaces or spaces where is risk of oil contamination of bilge water
  - Bilge water to be collected to tank for separation or pumping to shore
  - Bilge water separator needed
  - System and monitoring to prevent pumping oily (<15ppm) water to sea (usually part of bilge water separator unit)
  - Own piping system

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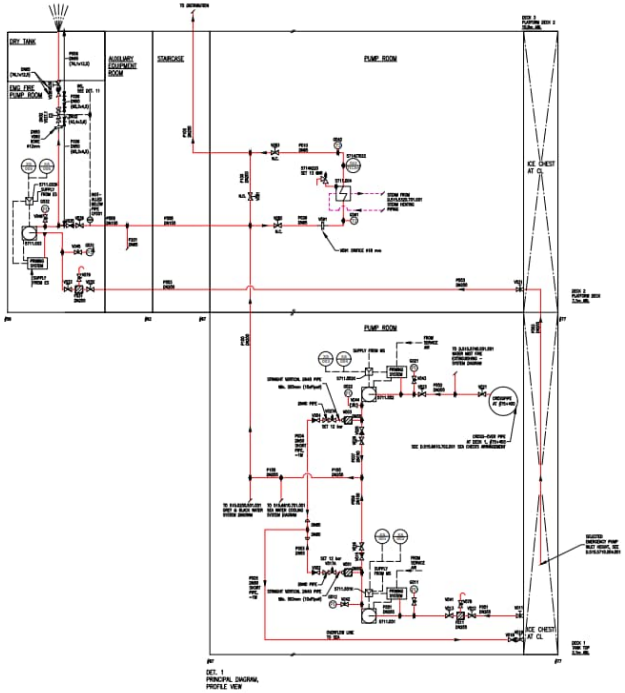
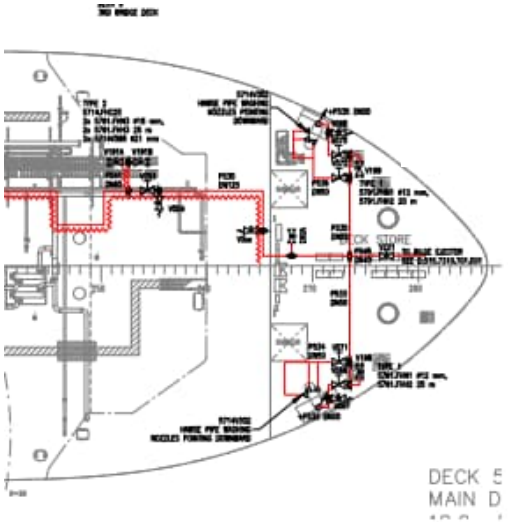
# Fire Main

- The system to have 2 main pumps and one spare with minimum 40% capasity(fed from EDG) in different compartment than the other pumps (usually in the bow)
- Pressurised piping, own expansion tank with feed and topping up from fresh water system
- Highly regulated by rules
- Generally system to dimensioned so that hoses from fire post will reach all locations onboard
- System to be designed so that it is possible to use fire posts even one part of pipe is damaged
- All water posts to have min 2,6 (2,8) bar pressure (3 posts open)
- All A-Class areas to have other fixed independent fire supression system (Foam, highpressure water system, Gas..)
- Other areas handheld equipments considered enough (hand held extinguishers)



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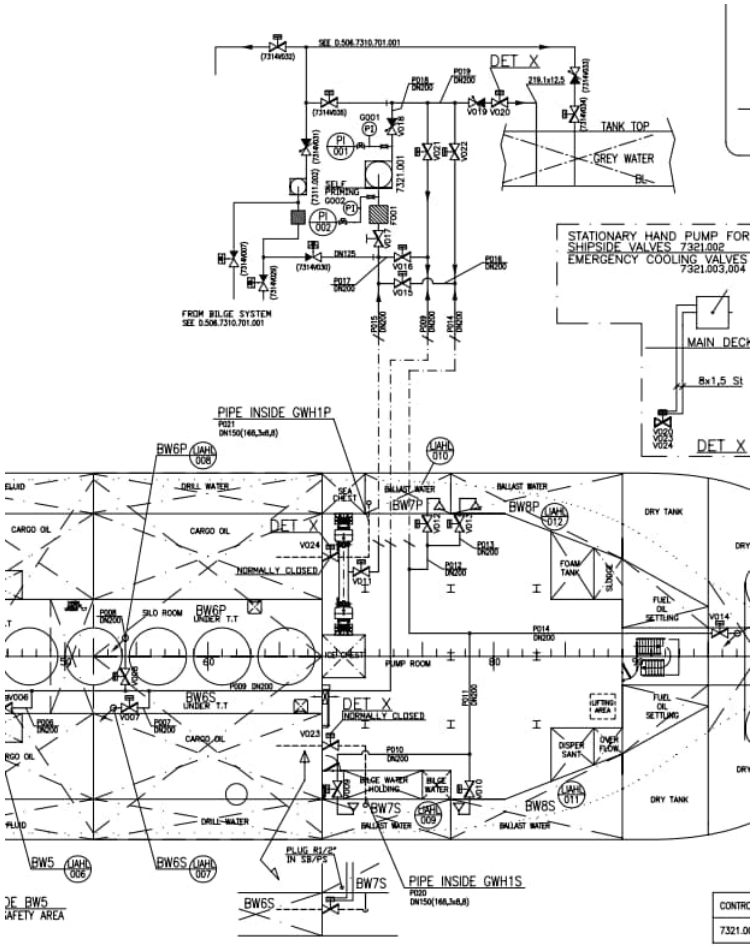
# Ballast system

- The system to have 2 pumps, other can be combined with bilge, fire or general service pump)
  - Typically centrifugal pumps with ejector for priming
- System is for pumping water to and from ballast tanks to keep draught, trim and heel in control
- Natural filling is used if possible
- Ballast system to have water treatment system (regulations due alien sealife)
- Usually big piping system
- Specially in cargo vessels
- Sea water, galvanized steel pipes (or GRP)

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# HVAC systems

- Potable water
  - From shore or produced with evaporator or RO-plant
  - Tank needed in all cases
- Technical water
  - Usually non mineralized water made with fresh water generator (see above)
  - Used for boiler feed water, engine cooling water, AC heating/cooling water and in laundry (if any)
  - Usually own system and tank for usage
- Gray Water
  - Water from sinks, dush, laundry and scuppers inside
  - Tank and possibility to hold water for agreed time (vessel purpose). Today often possibility to pump water to shore
  - Water from galley usually have grease separation
  - Usually free flow system (Normal sewer), to be designed carefullu with fall
- Black water
  - Water from toilet and urinals
  - Own system usually vacuum type for water saving
  - Holding tank, pumping to shore
  - Bigger vessels (Passenger vessels) have treatment plant (possibility to pump overboard)
  - ”Shit runs also upwards”
- AC cooling
  - Chilled water or direct expansion system to cool outside air
  - Water used in bigger systems (10~17°C), cooled with AC compressors
  - In big cruise vessels biggest system (in pipe and pump size)
  - Usually can be used as pre heating in cold climates
- AC heating
  - (re)Heating water used to heat AC air after cooling (drying air) to required temperature
  - Heated with boilers or heat recovery

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# Thank you!

**“Shipbuilding is just a big logistical problem”**