California Maritime Technical Working Group

Focus on Fuel Switching

Fuel Oil Systems

July 24, 2007

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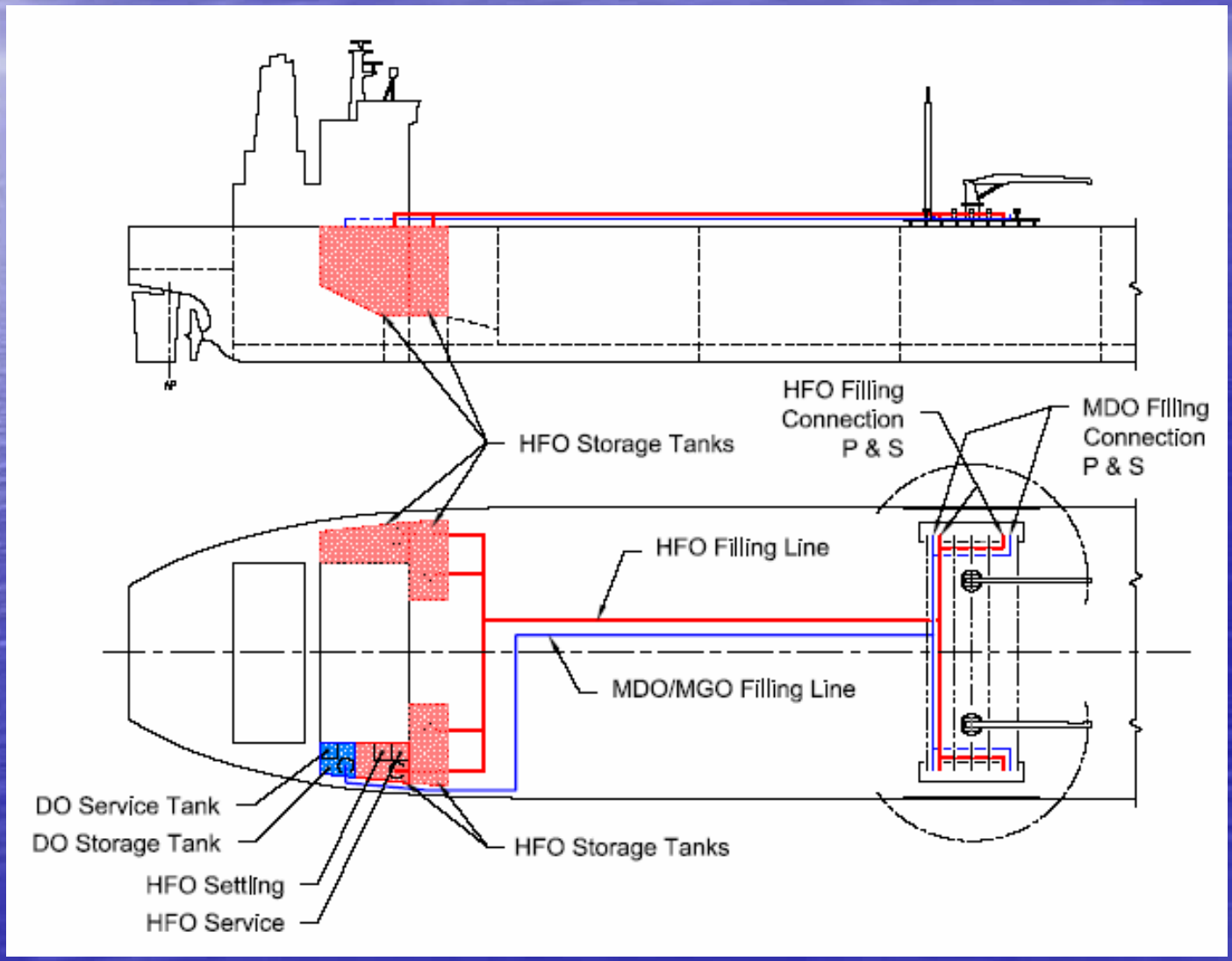
Evolution of Modern Fuel Systems for Ships

- For the last 50 years, marine engine builders have focused on reducing fuel cost by improving efficiency and using less expensive fuels.
- Once main engines were developed to operate on heavy residual fuel (HFO), generator engines were developed to also run on HFO – the "Unifuel" ship.
- Nearly all current designs are Unifuel, that is everything is designed to run on a single fuel - HFO.
- Relatively small amounts of lighter distillate oil are carried for long term shutdown and emergency use when heating steam is not available.

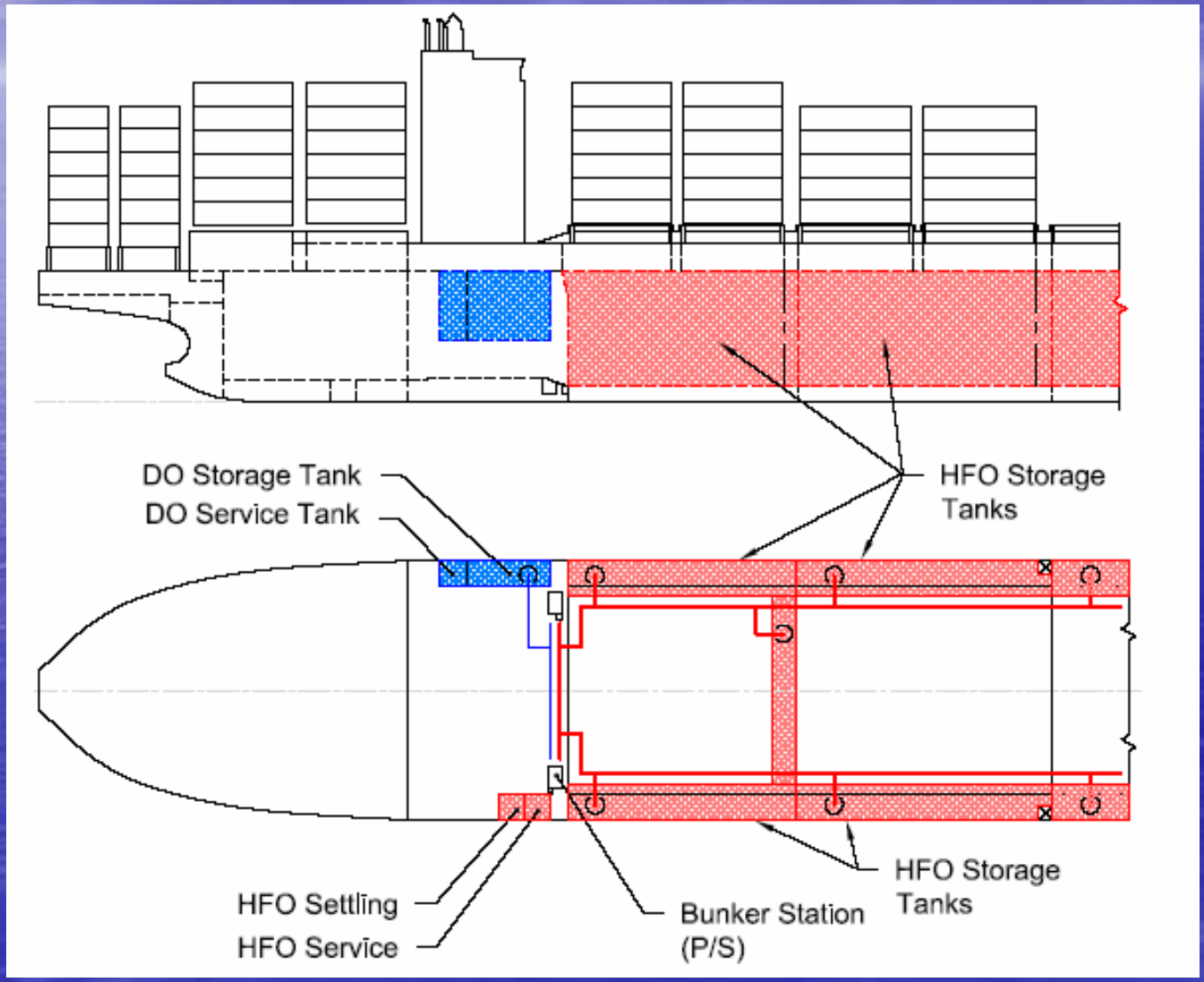
Common Features for All Ships

- Minimum space practical is devoted to fuel and machinery to maximize cargo.
- With unifuel ships, minimal space is provided for distillate oil tanks.
- Some ships have two HFO tank systems:
  - One for regular HFO (2.3 to 2.7% S; 4.5% max)
  - One for Low Sulfur HFO (1.0 to max 1.5% S)
- Distillate oil is usually MDO with about 0.5% sulfur.

Tanker: Typical Fuel Tanks and Filling System



Containership: Typical Fuel Tanks and Filling System



Typical Bunker Tank Arrangement Tankers

Ship Type/Size	HFO		MDO	
	Description	m^3	Description	m^3
50,000 DWT Panamax	2 HFO stor + 1 Sett + 1 Serv	1,500	1 DO Stor + 1 Serv	150
110,000 DWT Aframax	4 HFO stor + 1 Sett + 1 Serv	3,000	1 DO Stor + 1 Serv	250
160,000 DWT Suezmax	4 HFO stor + 1 Sett + 1 Serv	4,000	1 DO Stor + 1 Serv	350
300,000 DWT VLCC	4 HFO stor + 2 Sett + 1 Serv	5,500	1 DO Stor + 1 Serv	450

Typical Bunker Tank Arrangement Containerships

Ship Type/Size	HFO		MDO	
	Description	m^3	Description	m^3
2500 TEU Feedership	6 HFO stor + 1 Sett + 1 Serv	3,200	1 DO Stor + 1 Serv	300
4000 TEU Panamax Containership	8 HFO stor + 1 Sett + 1 Serv	7,000	1 DO Stor + 1 Serv	350
6000 TEU Post-Panamax Containership	10 HFO stor + 2 Sett + 1 Serv	8,000	1 DO Stor + 1 Serv	400
9000 TEU Post-Panamax Containership	12 HFO stor + 2 Sett + 2 Serv	10,000	2 DO Stor + 1 Serv	800

At Sea Cruising Range when Burning Distillate in ME and Aux.

Ship Type/Size	Days	Naut. Miles
Panamax Tanker	3.3	1,200
Aframax Tanker	3.5	1,300
Suezmax Tanker	3.6	1,300
VLCC	3.3	1,200
2500 TEU Feedership	2.6	1,300
4000 TEU Panamax Containership	1.9	1,100
6000 TEU Post-Panamax Containership	1.7	1,000
9000 TEU Post-Panamax Containership	1.8	1,100

Range assumes 15% reserve

Viscosity of Distillate Oil

- ISO viscosity specifications for marine distillates:

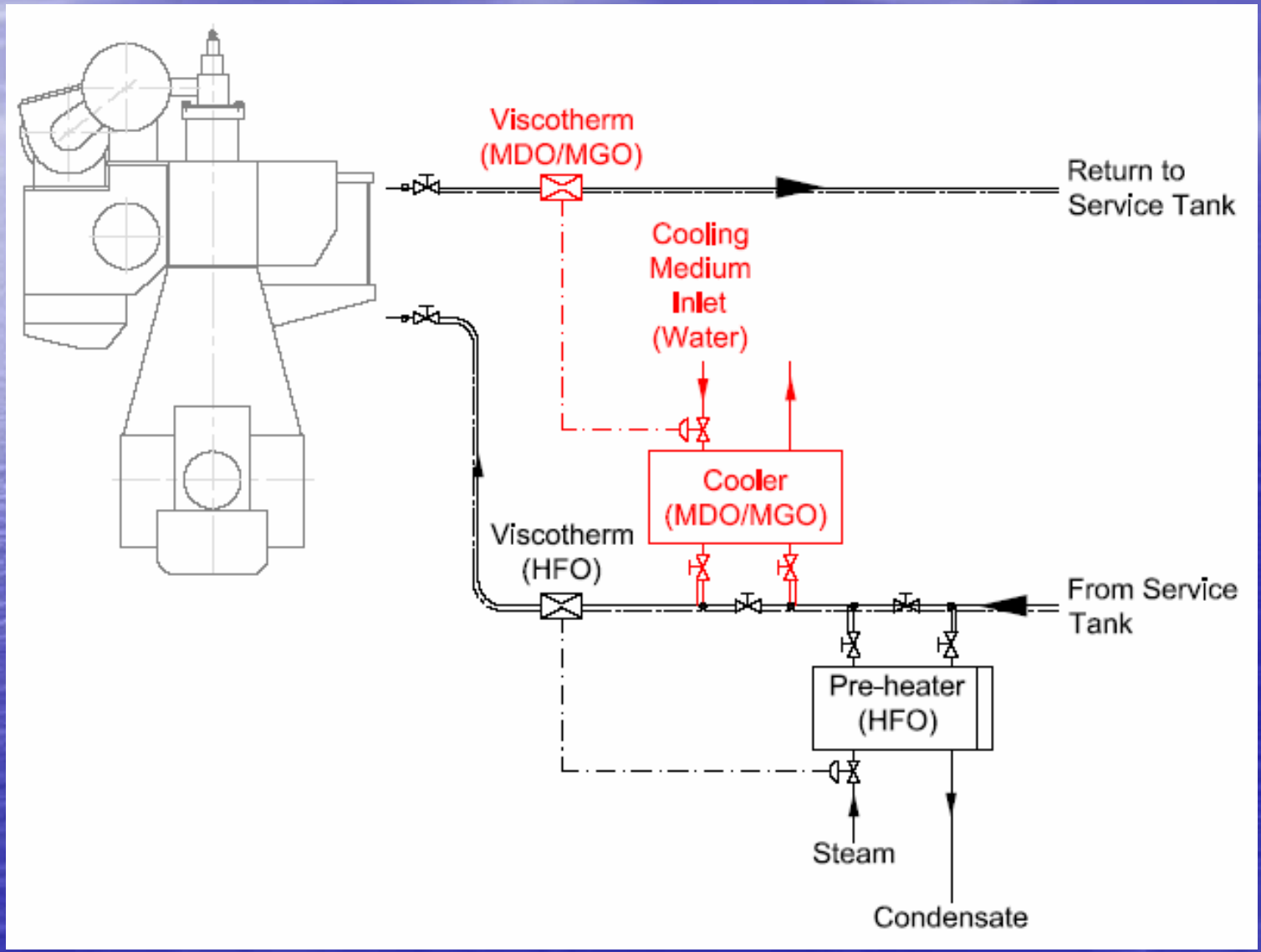
MGO	ISO-F-DMA	1.5 to 6.0 cSt
MDO	ISO-F-DMB	2.5 to 11.0 cSt

- Most U.S. suppliers will guarantee MGO with a minimum viscosity of 1.9 cSt. Some will only guarantee the ISO minimum of 1.5 cSt.
- Available diesel fuel in California is primarily road quality, with a viscosity range of 1.9 to 4.1 cSt.
- These viscosity figures assume the oil at 40°C. On marine vessels, the temperature of the oil will normally rise above this temperature, further reducing the viscosity.

Viscosity of Distillate Oil

- As currently built, marine diesel engines are suitable for continuous operation on distillate with viscosity down to 2.0 to 2.5 cSt. Below this level, there are maintenance concerns with the fuel injectors and pumps.
- For extended operation on MGO, it may be necessary to cool lower viscosity diesel oil to increase the viscosity above 2.0 cSt.
- This is most easily accomplished by installing coolers in the fuel lines supplying the main and auxiliary engines. This modification is straightforward, and can generally be done within the space available on existing vessels.
- With lower viscosity distillates, some reduction in ship speed may result from the pumps delivering less fuel and preventing the engine from developing full power. Pumps for new vessels can be designed to maintain full power.

Fuel Oil Cooler Arrangement



Conclusions

- Existing diesel oil tank capacities should be sufficient to accommodate burning distillate oil in main engine and auxiliary diesel engines for limited operations within 24 nautical miles of California.
- Existing systems are suitable for continuous operation on MDO (sulfur content of about 0.5%).
- 0.1% sulfur fuel means burning MGO. Operators will generally not carry both MDO and MGO, but will utilize the existing MDO system for MGO.
- Coolers may be needed to maintain the viscosity at minimum levels. This can readily be accomplished at a ship's normal drydocking.