4th Public Workshop to Discuss Development of Regulations for Ocean-going Ship Main Engines and Auxiliary Boilers

Worldwide Marine Distillate Fuels Properties-DNV 2007 Data

March 5, 2008
Sacramento, CA

California Environmental Protection Agency
AIR RESOURCES BOARD

Overview

- ARB purchased data on marine distillate fuel properties from Det Norske Veritas (DNV)
- Presentation provides ARB analysis of DNV data
  - ARB's views and conclusions (not DNV's)
- Evaluation of DNV data is one part of the technical evaluation for the ship main engine rule
- Other studies include evaluations of fuel samples taken from enforcement efforts, lubricity testing, and long-term fuel switching study

DNV Petroleum Services Data

- DNV analyzes marine fuels worldwide for compliance with ISO specifications
- Extensive database of test results kept
- Results presented represent 2007 marine distillate data from 21 ports worldwide
  - Ports selling low, medium & high sulfur fuels
  - Preference to high volume bunkering ports
  - Preference to Pacific Rim ports

Fuel Data Analyzed from Bunkering Ports Worldwide

- Augusta (IT)
- Busan (KR)
- Dubai (AE)
- Durban (ZA)
- Fujairah (AE)
- Gibraltar (GI)
- Hamburg (DE)
- Hong Kong (HK)
- Houston (US)
- Kaohsiung (TW)
- Los Angeles (US)
- Panama Canal (PA)
- Rotterdam (NL)
- San Francisco (US)
- Seattle (US)
- Shanghai (CN)
- Singapore (SG)
- Suez (EG)
- Tokyo Bay (JP)
- Valparaiso (CL)
- Vancouver (CA)

Analysis of Distillate Fuel Properties

- Sulfur Content
  - Determine number of samples meeting 0.1% and 0.2% sulfur levels
- Viscosity of Fuel
  - Compare measured values with levels recommended by engine manufacturers
  - Evaluate relationship with sulfur content
- Flash Point
  - Determine compliance with ISO Specifications

Selected ISO Specifications for Marine Fuels

Property	On-road Diesel*	DMA (MGO)	DMB (MDO)	IFO 180	IFO 380
Sulfur (% by wt.)	0.0015 (15 ppm)	1.5	2.0	4.5 (IMO)	4.5 (IMO)
Viscosity (cSt @ 40 ◦C)	1.9 to 4.1	1.5 to 6.0	11 max.	180 max @ 50 ◦C**	380 max @ 50 ◦C**
Flash Point (◦C min.)	52	60	60	60	60

* Onroad ASTM 975, S15 Specifications

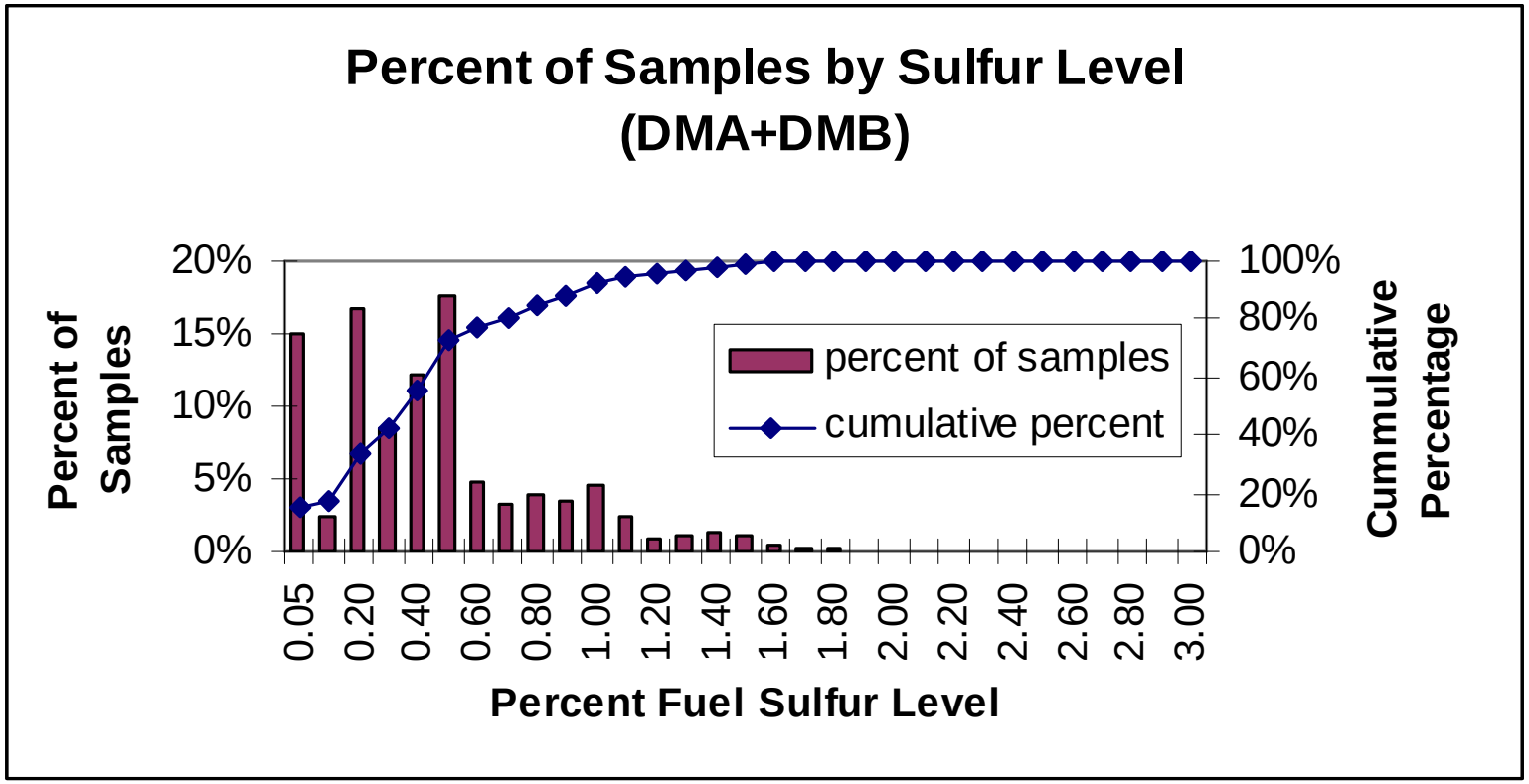
** 180 cSt @ 50◦C~ 7 cSt @ 150C, 380 cSt @ 50 ◦C ~9 cst@150C per ISO 8217

Range in Fuel Sulfur Content of Marine Distillate Fuels Analyzed*

Fuel Type	Min % S	Max % S	Ave % S
DMA	0.05	1.70	0.39
DMB	0.05	2.12	0.54
DMA+DMB	0.05	2.12	0.43

*DNV PS 2007 data. Samples tested at or below 0.05% sulfur listed as 0.05% sulfur

Fuel Sulfur Content Distribution



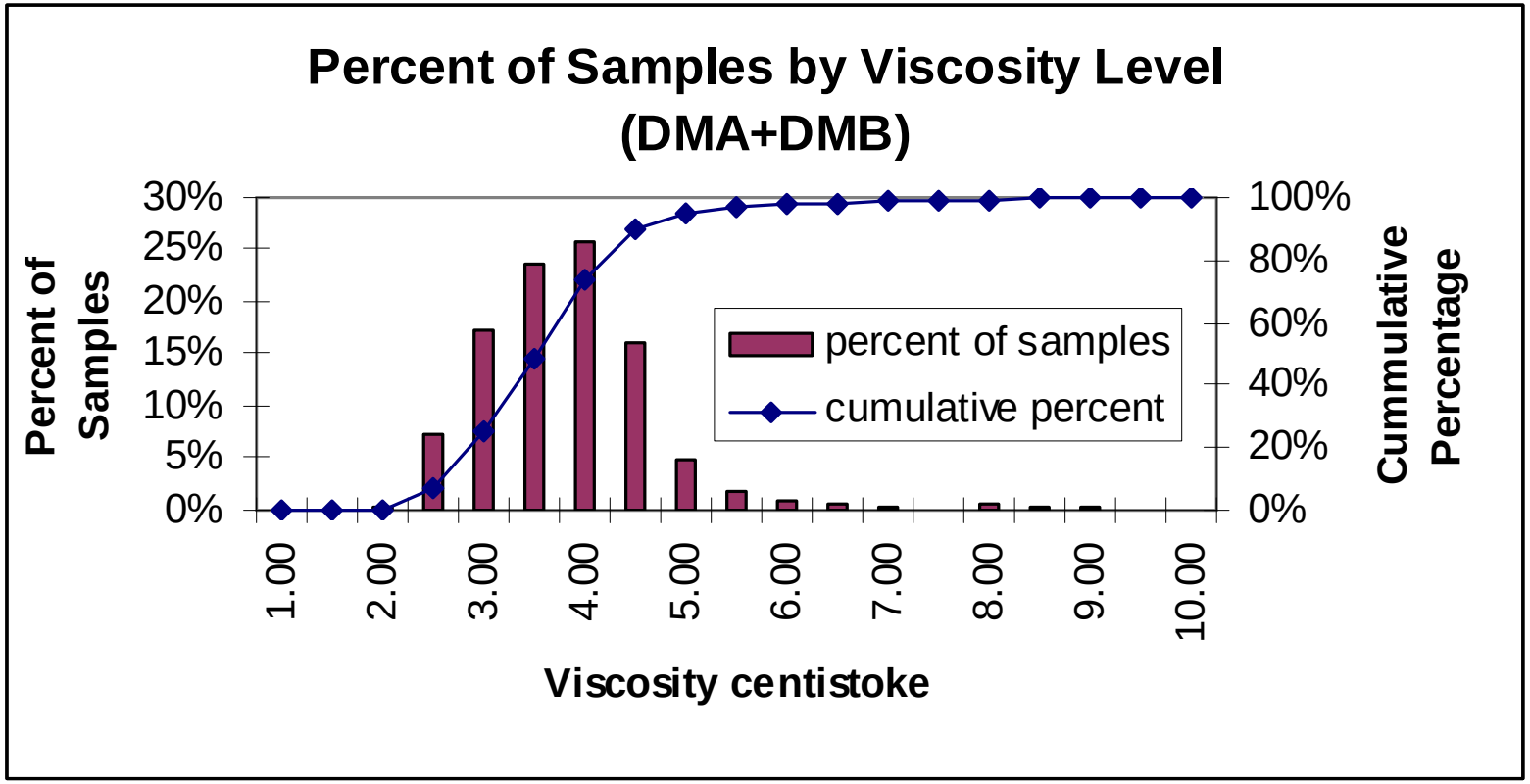
DNV Petroleum Services 2007 Data

Range in Fuel Viscosity of Marine Distillate Fuels Analyzed

Fuel Type	Min cSt	Max cSt	Ave cSt
DMA	1.53	9.72	3.51
DMB	1.97	9.93	3.93
DMA+DMB	1.53	9.93	3.61

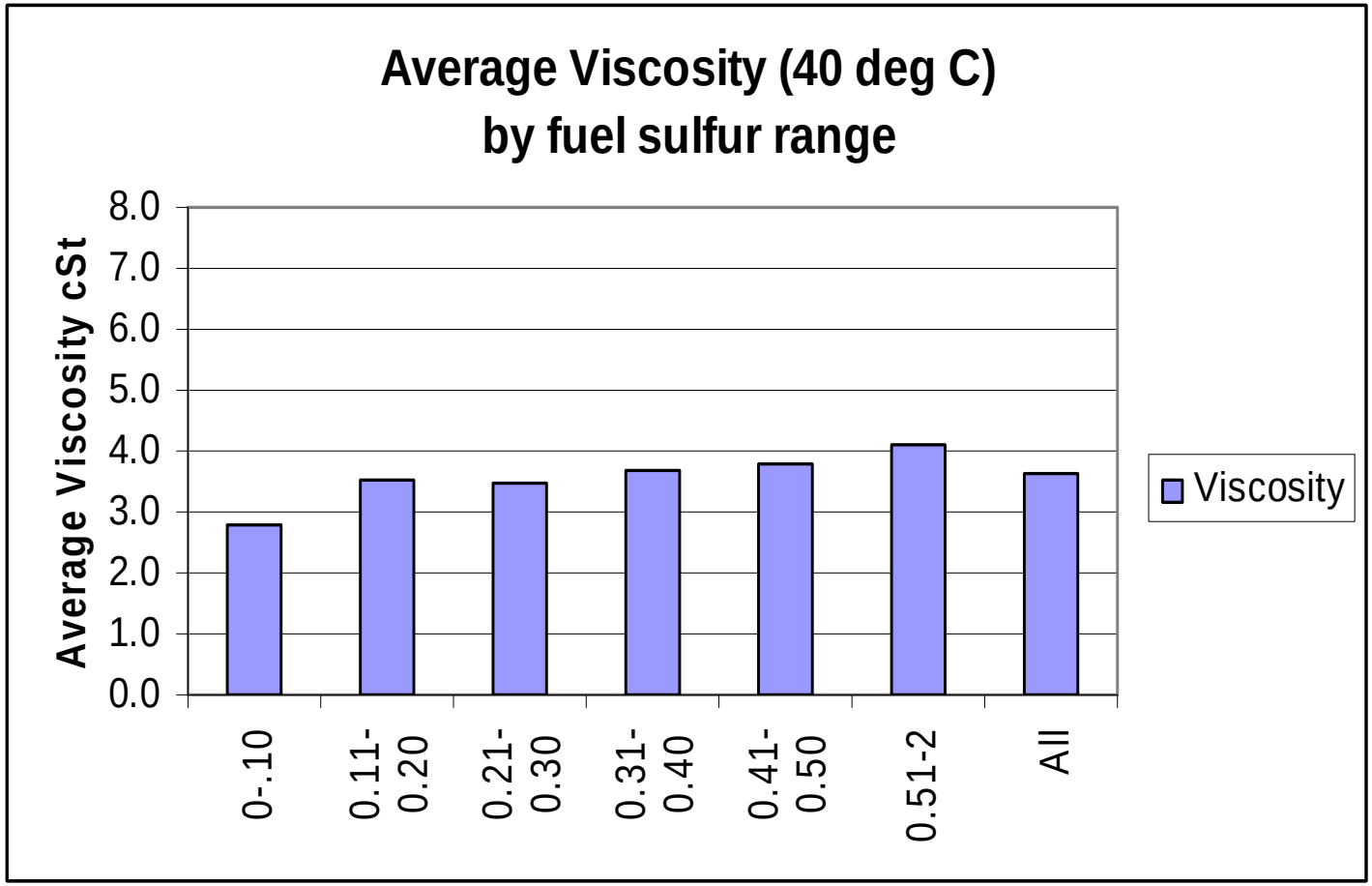
DNV Petroleum Services 2007 Data

Fuel Viscosity Distribution



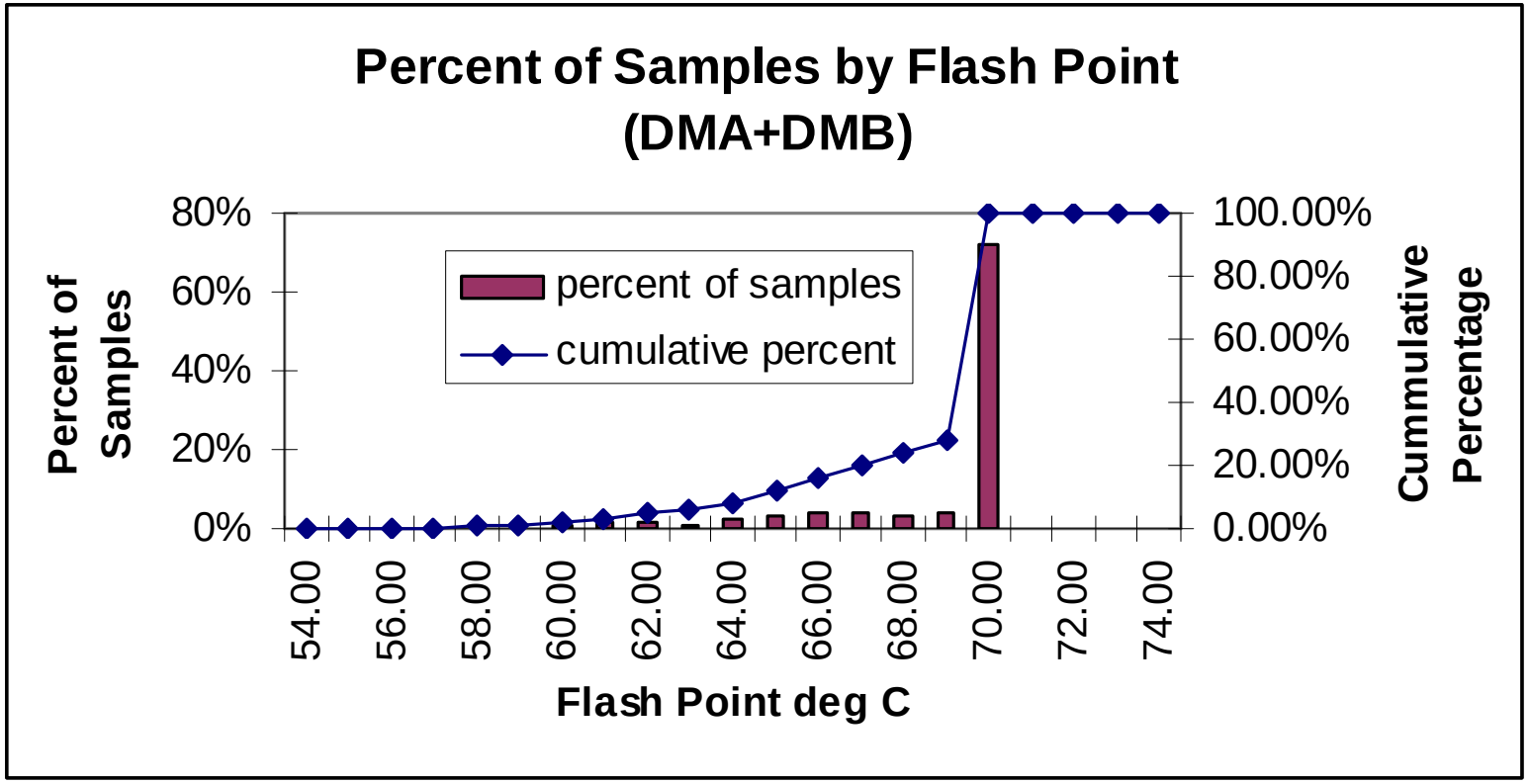
DNV Petroleum Services 2007 Data

Average Viscosity Levels by Fuel Sulfur Range



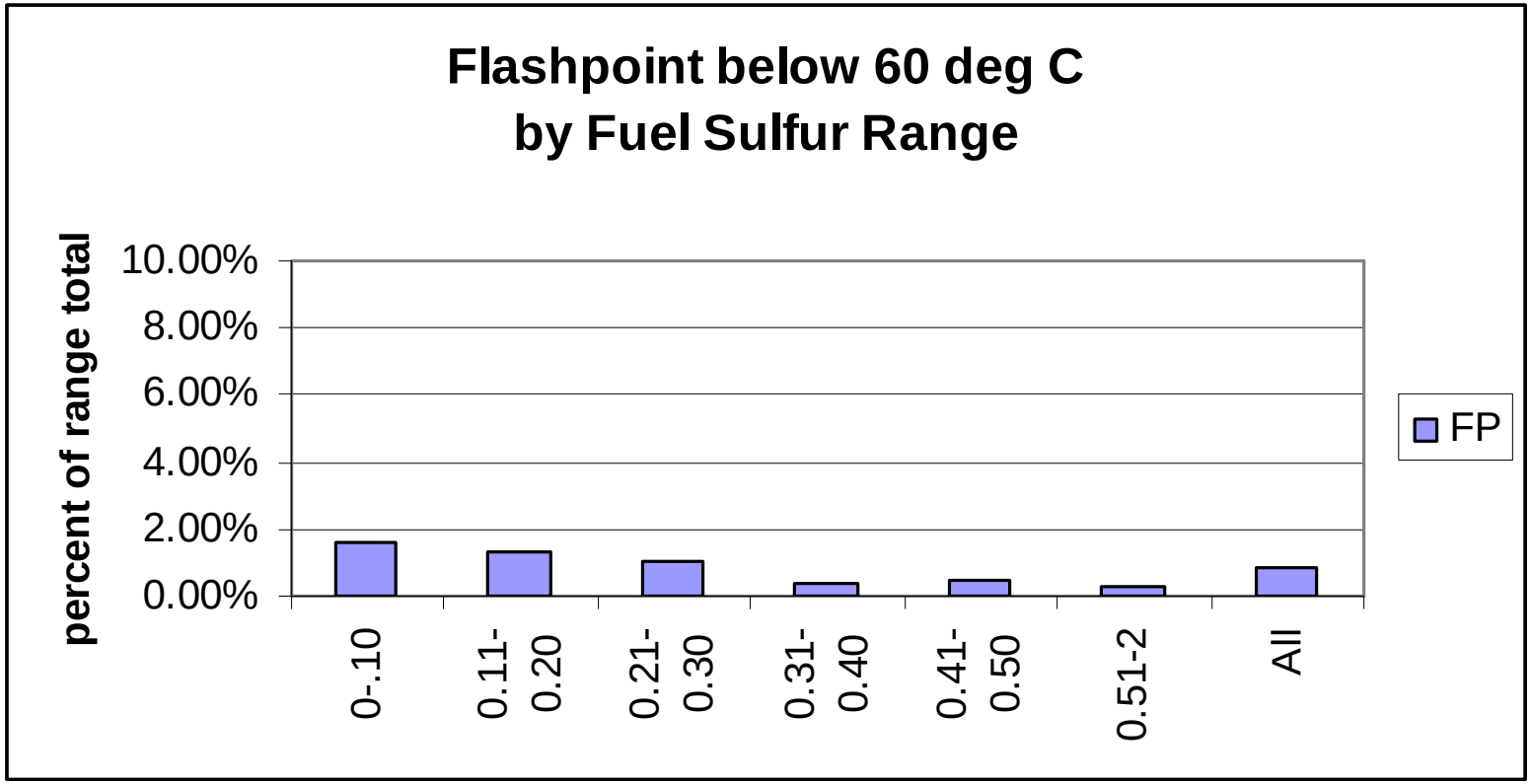
DNV Petroleum Services 2007 Data

Fuel Flash Point Distribution



DNV Petroleum Services 2007 Data

Percentage of Fuel Samples Below Flash Point Limit by Fuel Sulfur Range



DNV Petroleum Services 2007 Data

Conclusions

- Sulfur Content
  - Wide range in sulfur content depending on bunkering port
  - Significant number of samples have a low sulfur content
  - Samples meeting 0.2% sulfur are about double those at 0.1%
- Viscosity of Fuel
  - Viscosity of distillate fuels is significantly lower than residual
  - Little correlation between sulfur content and viscosity
  - Almost all fuel samples are above the 2cSt level recommended by engine manufacturers
  - Some fuel samples have borderline viscosity
- Flash Point
  - Not a strong correlation observed between sulfur % and flash pt.
  - Very few samples do not meet minimum flash point (~2%)

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