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

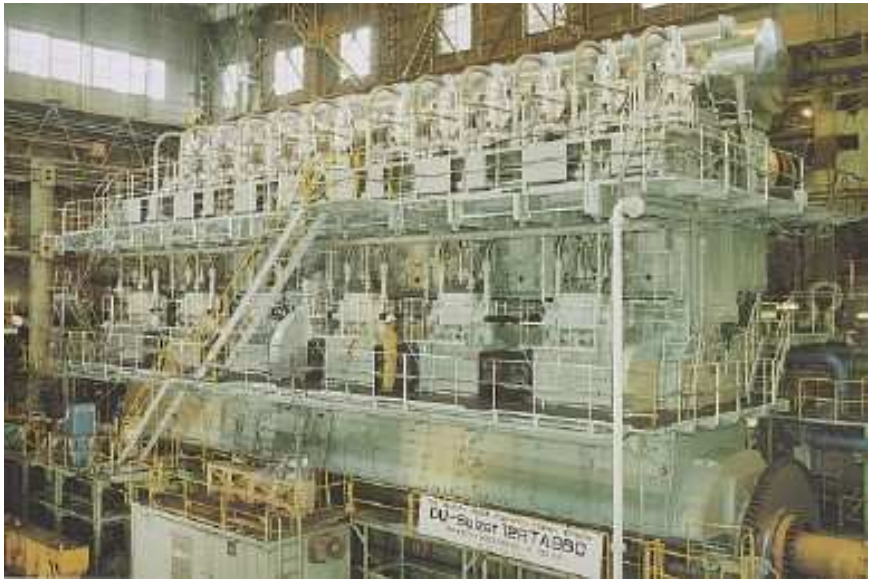
OGV Voluntary and Test Programs

March 5, 2008
Sacramento, CA

California Environmental Protection Agency
AIR RESOURCES BOARD

Marine Voluntary and Test Programs

- **Detailed data from Maersk's Voluntary Fuel Switch Initiative**
- **Test Programs**
  - **lubricity and fuel property testing**
  - **fuel pump bench testing with low viscosity and/or low lubricity distillate fuel**
  - **evaluation of long-term impacts on main engines from frequent fuel switching**



Maersk Voluntary Fuel Switch Initiative
-Information Requested

- **Voluntary program initiated by Maersk**
- **Started with Sine Maersk on March 31, 2006**
- **All ships calling in California switch to clean fuel in main and auxiliary engines**
  - **main Engines: within 24 nm from arrival port**
  - **auxiliary engines: within 24 nm from California baseline**
- **Cleaner fuel ≤0.2% sulfur MGO**
- **ARB has requested and is receiving detailed information from Maersk**

Maersk Voluntary Fuel Switch Initiative
-Information Requested

Vessels

- Number of vessels and California ports visited under the project
- Engine makes and models covered under the project
- Fuel delivery systems on participating vessels

Maersk Voluntary Fuel Switch Initiative
-Information Requested

Cleaner Fuels

- **Why was 0.2% sulfur fuel selected (as opposed to 0.1% sulfur)**
- **Primary locations/port/broker of distillate fuel purchases**
- **Actual sulfur content and fuel properties of the 0.2% sulfur distillate fuels**
  - **viscosity**
  - **density**
  - **flashpoint**

Maersk Voluntary Fuel Switch Initiative
-Information Requested

Operational Factors

- **Distillate fuel temperature at the primary fuel pump that may impact fuel viscosity**
- **Time (hrs.) on distillate per visit, typical or ship specific total hours per month or year on distillate.**
- **Fuel switching procedures**
- **Range of engine loads/maximum load during switching and while on distillate?**
- **Cylinder lubricants used**
- **Any fuel additives used**

Maersk Voluntary Fuel Switch Initiative
-Information Requested

Performance and Long Term Impacts

- **Maintenance and inspection data showing any changes in engine wear or performance that can be attributed to fuel switching,**
- **Have there been any problems with main engine associated with fuel switching or using distillate?**

Test Programs

- **Test programs underway and planned**

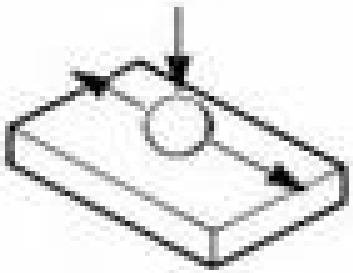
  1. **Lubricity and fuel property testing**

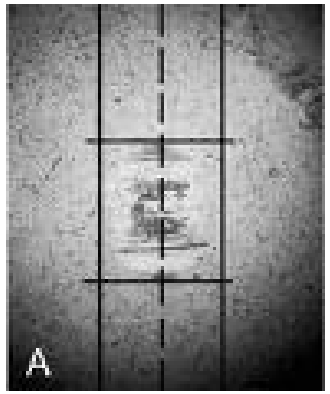
  2. **Fuel pump bench testing with low viscosity and/or low lubricity distillate fuels**

  3. **Evaluation of long-term impacts on main engines from frequent fuel switching**

Lubricity and Fuel Property Testing

- Testing in-use distillate samples from auxiliary engine enforcement activity
- Total of 20 MGO and 4 MDO samples
- Lubricity testing using High-Frequency Reciprocating Rig (HFRR).
  - **ASTM D6079/ISO 12156-1 HFRR**
  - **25, 40 and 60 deg C**





Lubricity and Fuel Property Testing

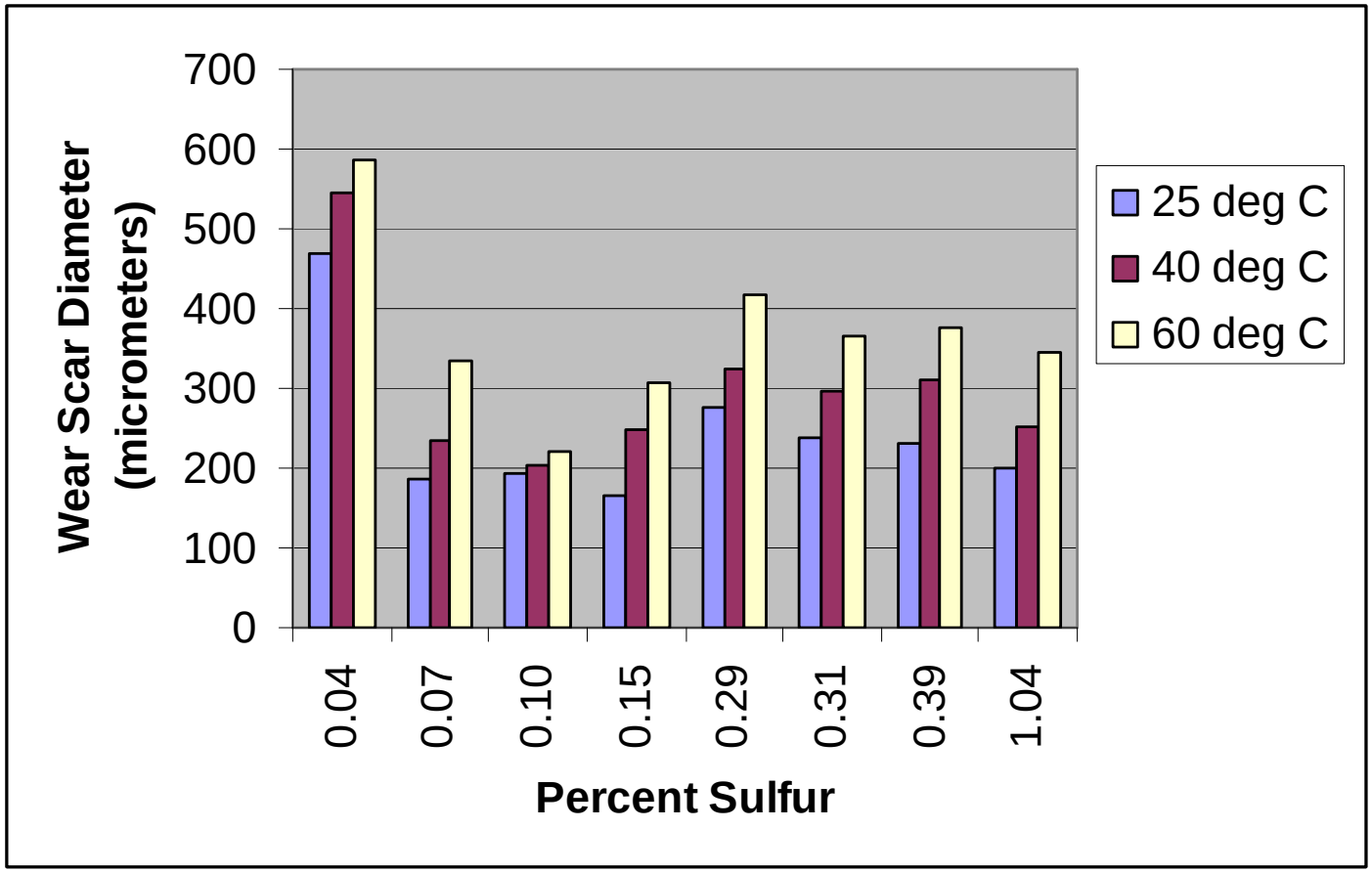
- Other fuel properties
  - **Cetane Index**
  - **Density at 15°C**
  - **Distillation (T10/T50/T90 distillation recovery temps)**
  - **Flash point (°C)**
  - **Sulfur content (% mass)**
  - **Viscosity at 40 °C (cSt)**

Lubricity and Fuel Property Testing

- Target sulfur content ranges for MGO and MDO samples
  - **0 to 0.1% (0 to 1000 ppm)**
  - **0.1% to 0.2% (1000 to 2000 ppm)**
  - **0.2% to 0.5% (2000 to 5000 ppm)**
  - **Greater than 0.5% (>5000 ppm)**
- Distillate from bunkering locations around the world

Lubricity and Fuel Property Testing- Samples Analyzed to Date (8)

Preliminary HFRR wear scar data



Lubricity and Fuel Property Testing- Samples Analyzed to Date (8)

Bunker Location City/Port	Bunker Country	Fuel Sulfur Percent	Fuel Type	WS diameter @40C	Viscosity @40C cSt
Manzanillo	Mexico	0.04	MDO	547	3.8
Tauranga	New Zealand	0.07	MGO May have additive	235	2.5
Los Angeles	USA	0.10	MDO	203	3.8
Busan	Korea	0.15	MGO	247	2.9
Hong Kong	China	0.29	MGO	323	3.8
Busan	Korea	0.31	MGO	297	3.4
Hong Kong	China	0.39	MGO	309	4.2
Rotterdam	Netherlands	1.04	MGO	251	3.9

Fuel Pump Bench Testing

The goal of this program is to determine the lower limits of fuel lubricity and viscosity for typical fuel injection pumps used on large two-stroke, slow-speed main engines

Program Description:

- **working in partnership with engine manufacturers**
- **bench testing on a simulated OGV "fuel injection pump rig test"**
- **injection pump typical of a large two-stroke, slow-speed engine**
- **operating on selected low sulfur marine distillate fuels**
- **fuel circulated through the pump for a specified period of time**
- **pump would be disassembled and inspected for wear**

Long-term impacts on main engines from frequent fuel switching

The goal of this program is to evaluate any long term impacts on large two-stroke, slow-speed main engines using engine monitoring, maintenance and inspection Data

Program Description:

- **partnering with shipping companies**
- **working with engine makers**
- **evaluate the long term impacts from frequent fuel switching**
- **any changes in engine component wear from baseline (HFO operation)**

Long-term impacts on main engines from frequent fuel switching

Evaluation will include:

- Changes in the piston, rings, and cylinder liner as viewed through scavenging port
- Any Increases in the following components
  - **cylinder liner wear beyond the normal baseline level**
  - **cylinder lubricant metal content as determined from "scrape down" program;**
  - **fuel injection pump leakage beyond the normal level**
  - **wear/scuffing in fuel injection pump plunger and barrel**
  - **leaks/seal replacement anywhere in the fuel system**
    - **types of seals failed**
    - **types of seals used as replacement**

Next Steps

- **Review data from Maersk's Voluntary Fuel Switch Initiative**
- **Continue to investigate the impacts of changing fuels**
  - **lubricity study and fuel properties**
  - **fuel pump bench testing**
  - **long term study on engine Impacts**