2nd Public Workshop to Discuss Development of Regulations for Ocean-going Ship Main Engines

June 13, 2007
Sacramento, CA

Overview

- Background
- Update on Ship Auxiliary Engine Regulation
- ARB Perspective on U.S. EPA and IMO Efforts to Reduce Ship Emissions
- Ship Survey Status
- Draft Regulatory Language
- Preliminary Estimates of Emissions Reductions
- Implementation Considerations
- Next Steps
Air Pollution is a Serious Public Health Concern

- Diesel PM identified as a Toxic Air Contaminant (1998)
- Non-Cancer Health Impacts of Diesel PM, SOx, Ozone
  - Premature death
  - Respiratory disease
  - Cardiovascular disease
  - Activity restriction
Emissions from Ships Impact Public Health and Air Quality

- Large and growing source of PM, NOx, and SOx emissions
- Emissions concentrated near population centers
- Significant localized and regional impacts
- Contributor to cancer risk and PM mortality
- Contributor to ambient levels of PM and ozone

Marine Vessels are a Large Source of California’s NOx & Diesel PM Emissions*

* Source: 2005 ARB Emissions Inventory. Does not include benefit of ARB Ship Auxiliary Engine Regulation
Multiple Drivers for Action

♦ Diesel Risk Reduction Plan
♦ State Implementation Plan
♦ Environmental Justice Programs
♦ Goods Movement Action Plan
♦ Port Emission Reduction Plans

Strategies to Reduce Emissions from Ships

♦ Rule prohibiting incineration for cruise ships and OGV (2005/2006)
♦ Port and Industry Environmental Programs
♦ Proposed Shore-Power Rule (late 2007)
♦ **Main Engine Fuel Rule (December 2007)**
♦ Voluntary Vessel Speed Reduction (late 2007)
♦ Green Ships Program (2008)
Update on Ship Auxiliary Engine Regulation

Regulation Applies to Auxiliary Engines and Diesel-Electric Engines on Ocean-going Vessels

Motor-Ship
- Main Engine for Propulsion (not covered)
- Auxiliary Engines for Electricity (covered)

Diesel-Electric
- Engines Provide Electricity for both Propulsion & Shipboard Uses (covered)
Regulation Applies Within 24 Nautical Miles of the California Coastline

Emission Limit Based on Use of Cleaner Distillate Marine Fuels

♦ January 1, 2007 Emission Limit
  – Use marine gas oil up to 1.5% sulfur
  – Use marine diesel oil with a 0.5% sulfur limit
  – Use equally effective emission control strategies

♦ January 1, 2010 Emission Limit
  – Use marine gas oil with a 0.1% sulfur limit
  – Use equally effective emission control strategies
  – Fuel supply review
**Option to Pay Noncompliance Fee**

- Unexpected redirection to a California port
- Inability to purchase complying distillate fuel
- Fuel found to be noncompliant enroute to California
- Extension needed for vessel modifications
- Vessel modifications needed on infrequent visitor

**Noncompliance Fee Schedule**

<table>
<thead>
<tr>
<th>Number of Port Visits</th>
<th>Diesel-Electric Vessels</th>
<th>Other Vessels</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>$32,500</td>
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<tr>
<td>2</td>
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<tr>
<td>5 or More</td>
<td>$162,500</td>
<td>$65,000</td>
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</table>
Alternative Control of Emissions (ACE)

♦ Operators may comply using alternative emission control strategies
♦ Must achieve equivalent or greater reductions
  – can use fleet average emission reductions
♦ Special provision encourages the use of shore-side power
♦ Must submit application for review
  – process includes opportunity for public comment

Marine Advisories and Notices

♦ August 2006 Marine Advisory Summarizing the Regulation Requirements
♦ 2006 Marine Notices
  – 2006-1: Safety Exemption
  – 2006-2: Noncompliance Fees
  – 2006-3: Recordkeeping
♦ 2007 Marine Notices
  – 2007-1: Fuel Mixtures
  – 2007-2: Definition of a “port visit”
  – 2007-3: Responsible parties under charter arrangements
Industry Compliance

- Nearly all ships complying by using the distillate fuels
- Three ship operators have paid noncompliance fees
- No Alternative Control of Emissions (ACE) applications
- No exemptions claimed for safety reasons

Enforcement Efforts

- Inspections at Ports throughout California
  - Over 60 vessels boarded
  - Fuels sampled
  - Ship records inspected
- Findings
  - Vessel operators aware of the regulation
  - Operators have been able to procure compliant fuel
  - Nearly 100% compliance
    - Two possible violations under investigation
Auxiliary Engine Inspection Results:
Average Sulfur Content Percentage by Weight

<table>
<thead>
<tr>
<th>Fuel Grade</th>
<th>Lab Rpt</th>
<th>Bunker Rpt</th>
<th>Avg Bnkr Rpt</th>
<th>Avg Lab Rpt</th>
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</thead>
<tbody>
<tr>
<td>MGO</td>
<td>0.299</td>
<td>0.238</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDO</td>
<td>0.195</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Fuels</td>
<td>0.238</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MGO Sulfur Content Percentage by Weight**

- Lab Rpt: 0.299
- Bunker Rpt: 0.238
- Avg Bnkr Rpt: 0.238
- Avg Lab Rpt: 0.238

Data Points

- Lab Rpt
- Bunker Rpt
- Avg Bnkr Rpt
- Avg Lab Rpt
Auxiliary Engine Inspection Results: MDO Sulfur Content Percentage by Weight

Auxiliary Engine Inspection Results: Comparison of S% and Flash Point
Auxiliary Engine Inspection Results: Comparison of S% and Viscosity

Ship Auxiliary Engine Rule Contacts

<table>
<thead>
<tr>
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<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
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ARB Perspective on U.S. EPA and IMO Efforts to Reduce Ship Emissions

U.S. EPA Regulation of Ships

- 2003 Rulemaking
  - NOx standards consistent with IMO Annex VI
  - only applies to U.S. flagged vessels
  - eliminates exemption for auxiliary engines on U.S. flagged vessels
  - Tier II standards to be proposed in April '07

- Recent direct final regulation to extend the deadline for Tier II standards

- Evaluating Sulfur Emission Control Area (SECA) for North America
U.S. Submittal to IMO

♦ Meet emission limits for PM and SOX equivalent to use of [0.1%] sulfur fuel
  – applies within [200] nm in sensitive regions
  – seawater scrubbers provide another option
♦ Tier II & III IMO new engine NOx standards
  – 15-25% below current IMO standards in 2011
  – 80% below tier II level in 2016 for defined areas
♦ NOx limits for existing engines
  – 20% reduction for [1985]–1999 engines in 2012

ARB’s View of US/IMO Efforts

♦ Prefer international or national emission control of ocean-going ships
♦ Support the US submittal to the IMO
♦ Disappointed with the national and international progress to date
♦ Need to move forward with state efforts until the IMO or EPA adopt measures to achieve the substantial emission reductions necessary to protect public health
Ship Survey Status

2007 Ship Survey

♦ Purpose
  – collect information on ships visiting California
  – support emission inventory updates and rulemakings for OGVs

♦ What Does the Survey Ask?
  – Part I: Contact/Company Information
  – Part II: Ship and Engine Information
    • what modifications were needed to comply with Auxiliary Engine Fuel Rule?
    • what modifications are needed to use low sulfur distillate fuel in main propulsion engines out 24, 50, 100 NM from CA baseline?

http://www.arb.ca.gov/msprog/offroad/marinevess/survey.htm
2007 Ship Survey

Status

- Survey was due by March 31, 2007
  - 77 companies responded
  - over 500 ships

- Participation is mandatory
  - higher return rate will result in a more informed rulemaking
  - ARB will be contacting ship owners/operators that have not yet submitted survey
  - information is critical for rulemaking
  - late submittals will be accepted

Draft Regulatory Language
Main Goals

♦ Require distillate fuels (MDO/MGO) as soon as possible in main engines
  – result in significant reductions earlier
♦ Align regulation with auxiliary engine rule
  – simplify implementation
  – minimize the need to carry multiple fuels

Main Engine Regulation is Aligned with Auxiliary Engine Regulation

♦ Retains the 24 nautical mile boundary
  – also includes provision to investigate boundaries further off-shore at a later date
♦ Contains similar elements
  – most definitions
  – safety exemption
  – recordkeeping
  – alternative control of emissions plan (ACE)
  – non-compliance fee
♦ Two-step implementation plan
  – distillate in 0.2-0.5% sulfur range in the near term
  – requirement to meet a 0.1% sulfur limit in the near future
OGV Main Engine Draft Regulatory Proposal

♦ Applicability
♦ Exemptions
♦ Definitions
♦ In-use operational requirements
♦ Non-compliance fee
♦ ACE
♦ Recordkeeping

Applicability

♦ All ocean-going vessels (U.S. and Foreign-flagged)
  – a vessel greater than or equal to 400 feet in length overall or 10,000 gross tons
♦ Main engine on an ocean-going vessel designed primarily to provide propulsion
  – with a per-cylinder displacement of greater than or equal to 30 liters
♦ All vessels operating within 24 nautical miles of the California coast
**Exemptions**

- Continuous and expeditious navigation through CA waters (no stops or port visits)
- Auxiliary diesel engines or diesel-electric engines
  - are subject to auxiliary engine rule
- Emergency generators
- OGVs owned or operated by any branch of local, state, federal, or foreign government within CA waters
- Main engines while operating on alternative fuels
- Safety exemption for severe weather conditions, equipment failure, fuel contamination, or other extraordinary reasons beyond the master’s reasonable control

**Definitions**

- Most definitions are aligned with the Auxiliary Engine Fuel Rule
- “Alternative Fuel” definition added
- “Emergency Generator” definition added
- “Ocean-going Vessel” definition modified to exclude ocean-going tugs
- “Port Visit” added and allows shifts within the port boundary
- “Voyage” definition added
Draft Regulatory Language

In-Use Operational Requirements

- Implementation Dates
- Fuel Requirements
- Boundary

Draft Regulatory Language

Fuel Requirements and Implementation Dates

- Two step phase in
  - require [0.2 - 0.5%] sulfur MGO/MDO for OGV main engines in 2009
    • actual limit to be determined during regulatory process
  - require 0.1% sulfur MGO in 2013 or 2014
    • date to be determined during regulatory process
- Tech review of availability of 0.1% sulfur MGO in 2012
**Draft Regulatory Language**

**Boundary**

- 24 NM from the California baseline (California Coastal Waters)
- Feasibility review in [2013-2014] to determine if should extend requirement beyond 24 NM

**Draft Regulatory Language**

**Noncompliance Fee Provision**

- Under specific conditions, allow payment of fees to comply with regulation
- Provide flexibility for ships that need significant modification to comply
- Allow a compliance path for circumstances beyond the vessel Master’s control
**Draft Regulatory Language**

**Noncompliance Fee Provision**

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**Draft Regulatory Language**

**Alternative Control of Emissions**

- Provide flexibility for compliance
- Public review process of application and ARB preliminary decision
- Must not result in greater emissions than direct compliance
- Need to determine how to calculate emissions equivalence
Draft Regulatory Language

Recordkeeping Requirements

- Keep the following records in English
  - date, local time, and position for:
    - entry into CA waters
    - initiation and completion of fuel switch prior to entry
  - type of fuel used in CA waters
  - type, amount, actual % sulfur of all fuels bunkered
  - fuel switching procedures

Preliminary Estimates of Emission Reductions
**Preliminary Estimates of Emissions Reductions**

**PM Emissions for Main Engine by S% (Includes Auxiliary Rule)**

![PM Emissions Graph]

*Baseline Main + Aux Rule*
*Main (.5%) + Aux Rule*
*Main (.3%) + Aux Rule*
*Main (.2%) + Aux Rule*
*Main (.1%) + Aux Rule*

*Note: 24 NM Boundary*

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**Preliminary Estimates of Emissions Reductions**

**SOx Emissions for Main Engine by S% (Includes Auxiliary Rule)**

![SOx Emissions Graph]

*Baseline Main + Aux Rule*
*Main (.5%) + Aux Rule*
*Main (.3%) + Aux Rule*
*Main (.2%) + Aux Rule*
*Main (.1%) + Aux Rule*

*Note: 24 NM Boundary*
Preliminary Estimates of Emissions Reductions

NOx Emissions for Main Engine by S% (Includes Auxiliary Rule)

Note: 24 NM Boundary

Implementation Considerations
Implementation Considerations

Information Gathering Efforts

♦ ARB held technical discussions in April/May
  – engine makers
    • MAN
    • Wärtsilä
  – vessel operators/owners that are using distillate in auxiliary and main engines
  – marine engineers/naval architects
♦ Efforts to continue during rulemaking
  – Maritime Working Group meeting (July 24th)
  – further technical discussions to address key considerations
  – encourage additional input

Implementation Considerations

Fuel Switching is Feasible

♦ Large two-stroke engines can operate on low-sulfur marine distillate fuels
♦ Several operational parameters need to be managed
♦ Ship-specific fuel switching procedures based on ship configuration are important
Implementation Considerations

Key Considerations

- Viscosity/fuel temperature
- Tankage/fuel system
- Fuel availability
- Fuel sulfur limit
- Cylinder lubricants and feed rates
- Length of operation on distillate
- Fuel switching procedures/crew training
- Fuel compatibility

Implementation Considerations

Fuel Viscosity

- Fuel pumps operate best with a viscosity greater than about 2 centistokes (cSt)
- ISO specification for DMA grade fuel (MGO) is 1.5 to 6.0 cSt@40°C (onroad diesel is 1.9-4.1)
- Most fuel from inspection reports is > 3 cSt
- Ship operators can increase fuel viscosity with a fuel cooler or fuel chiller
- Some ship operators may be able to specify a minimum fuel viscosity
Implementation Considerations

Tankage and Fuel System

♦ Some vessels may need to modify their tanks and fuel handling system to increase their capacity for distillate fuel & to aid fuel switching
  – Add a new tank
  – Segregate an existing tank
  – Costs expected to be in the range of $50 to $100k for a typical cargo ship

♦ Some vessels may be able to convert an existing HFO tank to distillate if a smaller HFO tank is available

♦ Fuel supply and recirculating pumps also operate best with a viscosity greater than 2 cSt

Implementation Considerations

Fuel Availability

♦ Critical aspect of rule implementation
♦ ARB cannot mandate requirements for foreign fuel suppliers
♦ Expect small increased demand due to main engine regulation
  – 300,000 tonnes marine distillate
  – ~1% of global demand for marine distillate
♦ Need a fuel sulfur limit that ensures global availability
Implementation Considerations

Fuel Sulfur Limit

♦ Distillate sulfur cap will depend on findings of fuel availability study
  – working with POLA/POLB on study
  – ARB analyzing available data on global availability of MGO or MDO in 0.1 to 0.5% sulfur range
♦ Concerned with global availability of 0.1% sulfur marine distillate
  – POLA fuel availability report
  – inspection results

Implementation Considerations

Cylinder Lubricants

♦ Lubricant properties are optimized for fuel and operating conditions
  – deposition rate
  – acid neutralization
  – detergent properties
  – oil film thickness
♦ Lubricating oils
  – base number of the lubricant (BN)
  – feed rate
♦ On-board lubricant management systems
  – MAN Alpha Adaptive Cylinder oil Control
  – Wärtsilä Sulzer TriboPack
Implementation Considerations

Adjustments to Cylinder Lubricant Depend on Length of Operation on Distillate

♦ Short duration fuel switching (< 72 hours)
  – may not require changes for lubricant type
  – may require changes in feed rate
♦ Longer duration fuel switching (>72 hours)
  – changes in lubricant and feed rate may be needed
♦ Typical ship operates main engine less than 30 hours in regulated zone
♦ Requires close monitoring of cylinder condition and following engine manufacturer’s guidelines

Implementation Considerations

Fuel Switching Procedures

♦ Fuel switching is currently conducted when ships prepare for dry-dock
♦ Ship specific procedures need to be followed to control changes in temperature & viscosity
  – prevent fuel gassing and fuel pump damage
♦ Equipment can be retrofitted to perform fuel switching automatically
♦ Segregated fuel systems allow for quicker fuel switches
  – separate settling and service tanks
Implementation Considerations

Crew Training

♦ Important to ensure that crews are trained in fuel switching procedures
♦ Fuel switching will be conducted more frequently for vessels visiting California
♦ Procedures available from engine manufacturers
♦ Procedures will vary with the vessel and can be either manual or automated

Implementation Considerations

Fuel Incompatibility

♦ Precipitation of asphaltenes in HFO possible with introduction of distillate
♦ Has not been an issue with the Ship Auxiliary Engine Rule
♦ Not unique to HFO/distillate fuel switches
♦ Minimize duration of time when fuels are mixed – i.e. segregated fuel systems
♦ Compatibility testing with onboard kit or in lab
Next Steps

♦ Maritime Technical Working Group
  – July 24, 2007
  – Discussion topics:
    • current global availability of distillate
    • fuel properties
    • switching procedures
    • greenhouse gas impacts
♦ Collect and analyze data from survey
♦ Continue to investigate fuel switching impacts
♦ Investigate fuel availability and cost impacts
♦ Monitor need to amend auxiliary engine rule
♦ Board consideration – December 2007
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