Evaluation of Ship Auxiliary Boilers for Inclusion in the Proposed Regulation for Ship Main Engines

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Sacramento, CA

Overview

♦ Why Regulate Auxiliary Boilers?
♦ Background
♦ Estimated Emissions and Potential Emission Reductions
♦ Feasibility of Using Distillate Fuel
♦ Costs and Cost Effectiveness
♦ Next Steps
Why Regulate Auxiliary Boilers?

- Significant source of emissions – mostly at dockside or close to shore
- Large potential reductions in PM & SOx
- Use of distillate fuel is feasible and cost-effective
- Practical to include boilers in main engine rule rather than separate rule

What is an Auxiliary Boiler?

- Closed vessel in which water is heated to produce steam
- Ship auxiliary boilers used for a variety of purposes (not ship propulsion)
  - Heat residual fuel
  - Heat viscous cargo
  - Hot water for crew/passengers
  - Space heating for cabins
  - Generate fresh water
  - Drive steam turbines pumps
Boiler Types

- Boilers, economizers, and composite units
  - Boilers are fuel-fired, economizers use exhaust heat (not covered), composite units do both
- Most boilers are fire-tube, water-tube, or a hybrid of both types
- Rated in terms of wt. steam/hr
- Different burners used
  - pressure jet
  - steam atomizing
  - rotary cup

Auxiliary Boiler Operation

- Cargo Ships
  - Boilers used in or near port when main engine is off or at low loads (economizer used at sea)
- Cruise Ships
  - May use boilers at all times due to passenger needs for hot water, space heating, etc.
- Tankers
  - Boilers used mostly in or near port
  - High loads when discharging cargo if equipped with steam turbine discharge pumps
Auxiliary Boilers are a Significant Source of Emissions

<table>
<thead>
<tr>
<th>2010 Uncontrolled Emissions (tons/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship Emissions Source</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Main Engines</td>
</tr>
<tr>
<td>Auxiliary Engines</td>
</tr>
<tr>
<td>Auxiliary Boilers</td>
</tr>
</tbody>
</table>

Source: ARB Emissions Inventory. Emissions within 24 nm of coastline. Assumes all auxiliary boilers use heavy fuel oil at 2.5% sulfur and there are no boiler emissions during transiting.

Auxiliary Boilers Emissions by Vessel Type

<table>
<thead>
<tr>
<th>2010 Uncontrolled Emissions (tons/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Type</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Auto Carrier/Roro</td>
</tr>
<tr>
<td>Bulk/General Cargo</td>
</tr>
<tr>
<td>Container Ship</td>
</tr>
<tr>
<td>Passenger/Cruise</td>
</tr>
<tr>
<td>Reefer</td>
</tr>
<tr>
<td>Tanker</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: ARB Emissions Inventory. Emissions with 24 nm of the California shoreline.
Potential Auxiliary Boiler Emission Reductions

<table>
<thead>
<tr>
<th>Emissions and Reductions</th>
<th>PM (tpd)</th>
<th>NOx (tpd)</th>
<th>SOx (tpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Emissions</td>
<td>1.3</td>
<td>3.3</td>
<td>26</td>
</tr>
<tr>
<td>Percent Reduction*</td>
<td>83%</td>
<td>6%</td>
<td>96%</td>
</tr>
<tr>
<td>Emission Reduction</td>
<td>1.1</td>
<td>0.2</td>
<td>25</td>
</tr>
</tbody>
</table>

* Emission reduction percentages based on change from 2.5% sulfur HFO to 0.1% sulfur MGO, and same reductions used for diesel piston engines.

Feasibility of Using Distillate Fuel - Input from Operators

♦ Most operators report few concerns with using distillate fuel in auxiliary boilers
♦ Tanker operators report the need for technical evaluations and possible modifications
  – Tankers using boilers for steam turbine discharge pumps have larger, higher pressure boilers
  – Modifications include new burner systems, controls, tanks and piping
  – Modifications more likely with older boilers
Feasibility of Using Distillate Fuel - Input from Manufacturers

- Existing boilers can use distillate fuels subject to certain technical considerations
- May need manual burner adjustment for optimal efficiency
- Fuel pumps on some older boilers may need to be replaced if fuel viscosity is too low, or fuel cooling installed to control viscosity
- Modifications to burners or control systems for some boilers

Using Distillate Fuel in Boilers would be Cost-Effectiveness

- Overall cost-effectiveness is expected to be similar to the ship auxiliary engine rule for SOx, but higher for PM (but still favorable)
- Most ship operators will not need to modify auxiliary boilers
  - Costs and cost-effectiveness will be driven mainly by the higher incremental cost of distillate fuel
- Tanker operators expected to incur higher costs
  - Costs for some vessels expected to include boiler or vessel modifications in addition to higher fuel costs
Typical per Visit Cost to Use Distillate Fuel in Auxiliary Boilers

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Boiler Use per Visit (hrs)</th>
<th>Fuel Use Rate (tonne/hr)</th>
<th>Fuel - MT per visit</th>
<th>HFO Cost ($)</th>
<th>MGO Cost ($)</th>
<th>Extra Fuel Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container</td>
<td>48 (dock) 2(at sea)</td>
<td>0.15</td>
<td>7.5</td>
<td>2,933</td>
<td>5,175</td>
<td>2,242</td>
</tr>
<tr>
<td>Cruise</td>
<td>11 (dock) 1 (at sea)</td>
<td>0.31</td>
<td>3.7</td>
<td>1,447</td>
<td>2,553</td>
<td>1,106</td>
</tr>
<tr>
<td>Tanker</td>
<td>38 (dock) 2 (at sea)</td>
<td>0.9 (dock) 0.11 (at sea)</td>
<td>34.4</td>
<td>13,450</td>
<td>23,736</td>
<td>10,286</td>
</tr>
</tbody>
</table>

Notes: Boiler use based on average ship time in mode (hotelling and maneuvering only) from the ARB Ship Auxiliary Engine Rule Staff Report. Fuel use rates from Starcrest 2005 POLA/POLB Emissions Inventory. Fuel prices from Bunkerworld.com on Sept. 18, 2007 averaging IFO-380 and MGO prices for Singapore, Houston, Rotterdam, and Fujairah -- $391/tonne HFO and $690/tonne MGO.

Next Steps

♦ Continue discussions with ship operators and boiler manufacturers
♦ Additional emissions testing of boilers
♦ Refine emissions inventory and emission reduction estimates
♦ Include auxiliary boilers in the regulatory process for the Ship Main Engine Rule
Contact Information

Bonnie Soriano  
(Lead Main Engine Rule)  
(916) 327-6888  
bsoriano@arb.ca.gov

Paul Milkey  
(Auxiliary Boilers)  
(916) 327-2957  
pmilkey@arb.ca.gov

Floyd Vergara  
(Legal Counsel)  
(916) 445-9566  
fvergara@arb.ca.gov

Peggy Taricco  
(Manager)  
(916) 323-4882  
ptaricco@arb.ca.gov

Dan Donohoue  
(Branch Chief)  
(916) 322-6023  
ddonohoue@arb.ca.gov

http://www.arb.ca.gov/marine