Introduction to Engineering Design
EDGSN 100 Section 002

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Introduction

Objective: Find a cost effective, emission friendly, and realistic solution to transporting freight

THE RATE OF POLLUTION IS TOO DAMN HIGH!
Pennsylvania’s infrastructure is one of the worst in the nation, with bridges, inland waterways, and roads all classified as Ds.

**ROADS**

- PA has a total of 41,000 miles of state highways and 79,000 local roads, 44% of which are rated fair to poor.

**WATERWAYS**

- PA has the third highest number of bridges in the country and the highest number of structurally deficient bridges, about 23%. Reconstruction has began!!

**BRIDGES**

- PA inland waterway system given an overall grade of D+, only 18% of the bridges were “satisfactory” rating. Pittsburgh was the busiest port in the nation in 2012!!
Standard Capacity for Alternate Transportation Modes

- The typical cargo ship capacity ranges from 1,500 tons for a single barge and 2,250 tons for a 15 barge tow. An average transport truck may hold up to 26 tons, and the capacity of trains ranges from 100 tons for a single car to 10,500 tons for an 100 car unit.
Barges and Railroads have had decreases in cost or are already low cost, making them more cost efficient than trucks!

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost per Mile</th>
<th>Evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>$1.68</td>
<td>Costs are increasing yearly, as well as road congestion and negative emission effects</td>
</tr>
<tr>
<td>Barge</td>
<td>$0.97</td>
<td>Least costly, but do produce environmental issues due to emissions</td>
</tr>
<tr>
<td>Railroad</td>
<td>$0.04</td>
<td>Cost per mile is drastically decreasing (43% less in last 30 years)</td>
</tr>
</tbody>
</table>
EPA Diesel Emission Standards

<table>
<thead>
<tr>
<th>Year of original manufacture</th>
<th>Tier of standards</th>
<th>Standards (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-1992&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Tier 0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NO&lt;sub&gt;X&lt;/sub&gt;: 8.0</td>
</tr>
<tr>
<td>1993&lt;sup&gt;a&lt;/sup&gt;-2004</td>
<td>Tier 1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>PM: 0.22</td>
</tr>
<tr>
<td>2005-2011</td>
<td>Tier 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>HC: 1.00</td>
</tr>
<tr>
<td>2012-2014</td>
<td>Tier 3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>CO: 5.0</td>
</tr>
<tr>
<td>2015 or later</td>
<td>Tier 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

* <sup>a</sup> - Tier 0 and Tier 1 standards were applied to new and used locomotives.
* <sup>b</sup> - Tier 2 standards were applied to new locomotives.
* <sup>c</sup> - Tier 3 standards were applied to new locomotives.
* <sup>d</sup> - Tier 4 standards were applied to new locomotives.

### Locomotive EPA emissions

- **Tier 0** (2000) - Unregulated
- **Tier 1** (2002)
- **Tier 2** (2005)
- **Tier 3** (2012)
- **Tier 4** (2015)

NO<sub>X</sub> (g/hp-hr) Reductions:
- Tier 4 to Tier 0: -76%
- Tier 3 to Tier 0: -70%
- Tier 2 to Tier 0: -50%
- Tier 1 to Tier 0: -25%

PM (g/hp-hr) Reductions:
- Tier 4 to Tier 0: -26%
- Tier 3 to Tier 0: -55%
- Tier 2 to Tier 0: -50%
- Tier 1 to Tier 0: -25%

**PM** - Particulate matter
**NO<sub>X</sub>** - Oxides of nitrogen
Diesel Engine Exhaust Emissions (DEEEE)

Emissions chemistry

**NO**\(_x\) \(\rightarrow\) NO\(_x\) (NO, NO\(_2\))

- NO\(_x\) (NO + NO\(_2\)) is formed when air (oxygen and nitrogen) is heated
- NO\(_x\) formation is exponential with temperature
  - Higher T → much higher NO\(_x\)
  - More time at T → much higher NO\(_x\)

PM

- Origin
- What it is
  - Fuel
  - Lube
  - Combustion Byproduct
  - Metals & Ash
  - Orgonics
  - Soot
  - Sulfates
  - Oil transfer past valve stems
  - Soot from Combustion
  - Oil transfer past rings

- PM - not a single substance - anything collected on test filter
- Delicate balance of compression, oil control & wear management

**CO**\(_2\)

\[ C_x H_y + O_2 \rightarrow C_2 H_2 O + \text{etc.} \]

\[ C_{in} = C_{out}, \text{ fuel consumption and CO}_2 \text{ production are directly related} \]

- \(\text{CO}_2\) is formed in direct proportional to fuel consumed
  - Reduce fuel consumption → reduce \(\text{CO}_2\)
  - Increase fuel consumption → increase \(\text{CO}_2\)
Locomotive Fleet Upgrade

- Upgrade from Tier 2 to TIER 4!!!!!!
- Get 2 barges for MAXIMUM CAPACITY!!!
- Sell the Tier 2 locomotives
Summary

We chose an environmental friendly solution that will hold for a long time

• Sell Tier 2
• Buy Tier 4
• Get 2 barges (Capacity)
• Get money ($$)$
Thanks for an awesome class Prof. B!!!!!!!!!!!!

(bye!)

(bye!)