An Assessment of the Evidence for the Carcinogenic Potential of Diesel Exhaust

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Evidence of Carcinogenicity of Diesel Exhaust

- **Cell Culture Studies**
  - Bioavailability, dose, composition issues
- **Chronic Animal Inhalation Studies**
  - Overload in rat studies, other species negative
- **Epidemiologic Studies**
  - Complex analysis and key for risk assessment

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Diesel studies have reported excess lung cancers in range of 30-40%.

- The two large studies, Garshick and Steenland, used for potential risk assessment by US EPA.
  - Garshick study did not show a dose-response relationship.
  - Steenland study mischaracterized the year dieselization occurred, lacked a dose-response, and had an inadequate latency period.
Diesel Epidemiology Studies

• Among the case control studies in meta analyses that were statistically significant and controlled for smoking results were inconclusive

• Literature reviews have been conflicting

• No studies of recent technology
Diesel exhaust likely carcinogenic for pre-1995 diesel
Data inadequate for quantitative risk assessment
Actual risk could be zero
Need for better studies on cancer
Reduction in all PM indicated
What’s New

• Elemental Carbon not a marker for diesel exhaust
• The trucking industry has had the same increased risk of lung cancer before and after dieselization and risks in Steenland similar for diesel and gas
• The Steenland study required a correction of the dieselization date and truckers don’t breathe own emissions
• Garshick reanalysis continues, a new study by Garshick of truckers will consider elemental carbon as a marker for combustion particulates not diesel

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What’s New

• Studies of miners with high diesel exhaust exposures do not show increased lung cancer risk
• Animal studies of post-1995 diesel technology do not show short term indicators of risk and a longer term study is now underway
Exposure is an Issue in Epidemiology Studies on DE

• Diesel is a minor part of exposures used for DE epidemiology studies
  – Particularly in studies reporting an association: railroad workers and truckers

• No unique marker for DE exposure

• Elemental Carbon used but 20-25% of gasoline exhaust

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Railroad and Trucker Exposure Studies

• Zaebst (1991) showed that for trucker exposures EC accounted for only 24% of total carbon in non-smokers.

• Whittacre (1999) found that EC was less than 10% of total carbon in electric utility workers using diesel trucks and equipment.


• Bunn (2003) found EC only 1-7% of particulate in diesel engine plant.

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Diesel Truck and Engine Plants Show Substantial Non Diesel Exposures

<table>
<thead>
<tr>
<th>Location</th>
<th>EC</th>
<th>TC</th>
<th>EC/TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck plants</td>
<td>2.3</td>
<td>42</td>
<td>5%</td>
</tr>
<tr>
<td>Engine plants</td>
<td>1.7</td>
<td>194</td>
<td>1%</td>
</tr>
<tr>
<td>Foundry</td>
<td>7.8*</td>
<td>112</td>
<td>5%</td>
</tr>
<tr>
<td>Test cells</td>
<td>11</td>
<td>139</td>
<td>7%</td>
</tr>
</tbody>
</table>

* EC likely from non-diesel sources such as carbon volatilized from molten iron
EC = Elemental Carbon;   TC = Total Carbon

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No Unique Markers For Ambient Exposure to Diesel Exhaust

• Health Effects Institute concluded that there are no specific or sensitive markers for ambient exposures to diesel exhaust (March 2003)

• Previous roadway studies claiming to be diesel exposure studies need to be reassessed

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Lung Cancer In Railroad Workers Not Related to DE

• Retrospective study by Garshick of 55,000 male railroad workers
• Train crews (intermediate exposure) - rate of lung cancer was elevated, but
• Shop workers (most highly exposed) – rate of lung cancer was not elevated
• Lung cancer rate did not increase with increasing duration of employment for any exposed group
• Reanalysis continues but no new data available. Both trucking and mining studies with exposure data now nearing completion
Lung Cancer In Truckers Not Related to DE

- Case-control study by Steenland of 1,288 cases of lung cancer in male Teamsters
- Adjusted odds-ratios 1.27-1.89 range
- Further analyses by others found
  - Exposure assessment issues – large, non-diesel, OC component
  - Inadequate latency period
  - Elevated lung cancer rates prior to dieselization
  - Lung cancer rates did not increase with dieselization
  - Truckers don’t breathe own exhaust
Mining Exposures to DE

- Diesel fueled equipment documented in mining for more than 60 years (sufficient latency)
- Exposures in mines using diesel are high (higher than other occupations by an order of magnitude)
- Many useful studies have been conducted on miners (often for effects of coal, silica, radiation, or other agents but also relevant to diesel)
Mine DE Exposures Are High

<table>
<thead>
<tr>
<th>Exposure Type</th>
<th>Mean (μg/m(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient</td>
<td>&lt;4</td>
</tr>
<tr>
<td>Truckers</td>
<td>10</td>
</tr>
<tr>
<td>Railroad workers</td>
<td>70*</td>
</tr>
<tr>
<td>US Surface miners</td>
<td>88</td>
</tr>
<tr>
<td>US Underground coal miners</td>
<td>640</td>
</tr>
<tr>
<td>US Underground metal/mineral miners</td>
<td>830</td>
</tr>
</tbody>
</table>

* Total particulate minus tobacco smoke

No Increase in lung Cancer for Miners Exposed to DE

- Lidell (1973) UK
  - Coal mine face workers SMR 0.49 [n.a.]
  - Underground coal SMR 0.53 [n.a.]
  - Surface coal SMR 0.82 [n.a.]
- Armstrong (1979) Aus coal SMR 0.2 [0-2.2]
- Saverin (1999) Ger potash SMR 0.78 [n.a.]
- Waxweiler (1973) US potash
  - Surface SMR 1.17 [n.a.]
  - Underground SMR 1.08 [n.a.]
- Morfeld (1997) Ger underground coal SMR 0.70 [.5-1.0]
- Strzynski (1997) Pol coal with pneuomoconiosis SMR 1.07
- Brown (1997) Aus coal SMR 0.74 [.5-1.06]
- Kirby (2000) Aus coal SMR 0.65 [.48-.96]

*C.I. = 95% Confidence Interval

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Lung Cancer in Miners Not Exposed to DE

- Goldman (1965) UK
  - Underground coal: SMR 0.70 [0.61-0.80]
  - Surface coal: SMR 0.92 [0.69-1.19]
- Boyd (1970) UK
  - Underground coal: PMR 0.79 [0.53-1.15]
  - Surface coal: PMR 0.99 [0.49-1.77]
- Rooke (1979) UK coal
  - PMR 1.17 [0.69-1.41]
- Enterline (1972) US coal
  - SMR 1.11 [0.3-2.85]
- Costello (1974) US coal
  - SMR 0.67 [0.43-0.99]
- Rockette (1977) US coal
  - SMR 1.13 [1.02-1.26]

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On-going Research

• Two large cohort studies
  – NIOSH/NCI Mining
  – Harvard Trucking

• Subacute and chronic animal studies
Summary and Conclusions

• Recent analyses provide less evidence for linkage between diesel exhaust exposure and lung cancer
• New studies nearing completion
• Only have studies on pre-1995 diesel technology
• Major changes in 2007 due to regulations
  – Composition will change
  – Diesel PM reduced by over 90%