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

Diesel Epidemiology Studies

- 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

CASAC Review

- 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

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

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
- Verma (1999) (2003) found EC exposure 2-16% of Railroad workers
- Bunn (2003) found EC only 1-7% of particulate in diesel engine plant

Diesel Truck and Engine Plants Show Substantial Non Diesel Exposures

	µg/m³		
Location	EC	TC	EC/TC
Truck plants	2.3	42	5%
Engine plants	1.7	194	1%
Foundry	7.8*	112	5%
Test cells	11	139	7%

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

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

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

Exposure Type	Mean ($\mu g/m^3$)
– Ambient [1]	<4
– Truckers [2]	10
– Railroad workers [3]	70*
– US Surface miners[4]	88
– US Underground coal miners[4]	640
– US Underground metal/mineral miners[4]	830

* Total particulate minus tobacco smoke

[1] EPA, 2000; [2] Zaebst, 1991; [3] Woskie, 1988 and Hammond, 1988; [4]MSHA 2000

No Increase in lung Cancer for Miners Exposed to DE

• Lidell (1973) UK		C.I.*
– 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 pneumoconiosis	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

Lung Cancer in Miners Not Exposed to DE

• Goldman (1965) UK		C.I.*
– Underground coal	SMR 0.70	[.61-.80]
– Surface coal	SMR 0.92	[.69-1.19]
• Boyd (1970) UK		
– Underground coal	PMR 0.79	[.53-1.15]
– Surface coal	PMR 0.99	[.49-1.77]
• Rooke (1979) UK coal	PMR 1.17	[.69-1.41]
• Enterline (1972) US coal	SMR 1.11	[.3-2.85]
• Costello (1974) US coal	SMR 0.67	[.43-.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%