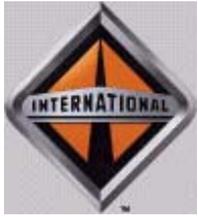




An Assessment of the Evidence for the Carcinogenic Potential of Diesel Exhaust

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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

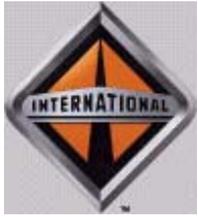
- Zebst (1991) showed that for trucker exposures EC accounted for only 24% of total carbon in non-smokers.
- Whittacre (1999) found that EC was less than 10% of total carbon in electric utility workers using diesel trucks and equipment
- Verma (1999) (2003) found EC exposure 2-16% of Railroad workers
- Bunn (2003) found EC only 1-7% of particulate in diesel engine plant



Diesel Truck and Engine Plants Show Substantial Non Diesel Exposures

<u>Location</u>	<u>EC</u>	<u>TC</u>	<u>EC/TC</u>
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

<u>Exposure Type</u>	<u>Mean ($\mu\text{g}/\text{m}^3$)</u>
– 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; ⁴MSHA 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]



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%