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Simulation of Automobile Brake Wear Dynamics and Estimation of Emissions

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ABSTRACT

Asbestos emissions from automobile brakes were measured under conditions simulating downtown city driving. Reference data for city driving was obtained by measuring vehicle speed, time of brake application, cool-down time between applications, brake hydraulic-line pressure and pad temperature. Data from 1800 braking applications were then analyzed to provide a statistical distribution of representative braking cycles.

We constructed a computer-controlled brake emission test rig that simulated road braking operation of a front wheel disc brake and collected airborne wear debris. Representative braking cycles were programmed on this system to experimentally estimate brake emissions under a variety of braking conditions.

Realistic braking operations produced particle and asbestos emission rates in close agreement with those measured by Williams and Muhlbaier. Asbestos concentration was not correlated with mechanical work done in braking.

Application of the asbestos emission rates to air quality models confirmed Williams and Muhlbaier's finding that about 1% of asbestos fibers in city core districts originated from disc brake wear.

TYPICAL ASBESTOS FRICTION PRODUCTS used in automobile brake linings and disc pads consist of three classes of materials: reinforcing agents, friction and wear modifiers, and organic binders. Reinforcing agents make up 40 to 50% (by weight) of the friction products and consist almost exclusively of chrysotile asbestos. Organic binders are primarily phenolic-type resins selected for high binding strength and comprise from 30 to 50% of the materials. Friction modifiers, which include polymeric, metallic, or ceramic materials, are added to maintain a proper range of friction coefficient or to control noise properties.

Friction materials in automobiles have been considered atmospheric emission sources and have been investigated by several researchers to define particulate and asbestos emission rates. There has been increasing evidence that the exposure of human beings to asbestos fibers can cause serious diseases, including mesothelioma, asbestosis, and cancer (1)*.

Jacko et al. (2) estimated the annual asbestos emissions from automobiles and concluded that 3.2% of the total automobile asbestos emissions are airborne, contributing only 2.3 t/yr to the atmosphere. Williams and Muhlbaier (3,4) found that airborne asbestos emissions from automobiles can account for only about 4.9 t/yr or 0.23% of the airborne asbestos emitted from all sources. Using the lead tracer model for automobiles, they predicted that automobile asbestos emissions contribute a small amount to the ambient asbestos level in New York City. The small contribution of automobiles estimated in these reports was primarily due to the low asbestos content of brake wear debris. The asbestos content ranged from 0.005 to 15% in other reports (4). This report presents a systematic approach to simulating brake applications and defining particulate and asbestos emissions.

TECHNICAL APPROACH

In the past, most brake abrasion rates and asbestos emissions were estimated by analyzing trapped debris in brake systems or by choosing arbitrary braking cycles and collecting corresponding samples. Accurate estimation, however, requires rigorous selection of representative braking cycles (RBC's) based on statistics, appropriate sample collection,

*Numbers in parentheses designate references at end of paper.

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