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MEMORANDUM

April 3, 2001

TO: Mike Brady (Caltrans)
CC: Dan Chang (UCD)
FROM: Doug Eisinger (707-665-9900)

SUBJECT: Carbon Monoxide Issues and Children's Exposure White Paper

Introduction

The Air Resources Board (ARB) has reservations about reducing the conformity hotspot carbon monoxide (CO) analysis requirements for areas that still exceed the standard. ARB staff have noted that ARB is reviewing health effects related to children and community-based problems, and is considering changes to the California air quality standards.

Given ARB's comments, Dan Chang raised questions related to children's CO exposure and health effects. This memo summarizes some recent information on the subject of children's exposure to CO and thresholds for adverse health effects. The memo summarizes for Caltrans information concerning whether children might be at risk for experiencing adverse health effects if exposed to CO concentrations below current national ambient air quality standards (NAAQS). The information is drawn primarily from two sources: a September 2000 California publication prepared by Dr. Michael Kleinman of U.C. Irvine, "Carbon Monoxide: Evaluation of Current California Air Quality Standards with Respect to Protection of Children" (Kleinman 2000), and the June 2000 CO Criteria Document prepared by the U.S. Environmental Protection Agency (EPA) (EPA 2000). The summary included in this memo will be helpful background material for discussions with ARB and EPA concerning whether it is appropriate to change the conformity CO hotspot analysis requirement.

Background on CO Health Standards and Percent Carboxyhemoglobin (%COBh)

CO health standards are based on studies that link ambient CO air quality concentrations to observed levels of carboxyhemoglobin (COBh) in the blood, and COBh quantity to observed health effects. CO competes with oxygen to bind to the heme portion of the hemoglobin (Hb)

molecules in red blood cells (Kleinman 2000, p. 2). The quantity of hemoglobin tied up by CO is referred to as %COBh.

Kleinman documents that California established health-based air quality standards based on keeping the concentration of carboxyhemoglobin (COHb) in the blood at or below 2.5% (Kleinman 2000, p. 3).

EPA found that the lowest level of COHb at which adverse health effects were demonstrated was 2.9 to 3.0%. Factoring in uncertainty and the need for an adequate margin of safety, EPA established 2.0% COHb as a level of concern (EPA 2000, p. 1-4). A 2.0% COHb level can result from exposure to approximately 12 ppm CO over 8 hours, or 33 ppm CO over 1 hour (EPA 2000; Figure 7-1, p. 7-3). However, EPA concluded that exposures resulting in 2.0% COHb would be dominated by indoor sources (e.g., tobacco smoke), over which the NAAQS would have no control, and felt it acceptable to keep the existing federal CO health standards (9 ppm for 8-hour, and 35 ppm for 1-hour) (EPA 2000, p. 1-5).

Table 1 includes California and federal CO health standards, and the COHb levels of concern used as the basis for the standards.

Table 1. California and federal CO health standards and COHb levels of concern.

Averaging Time	California Health Standards	Federal Health Standards
1-hour	20 ppm	35 ppm
8-hour	9 ppm (6 ppm for areas above 4,000 feet in elevation)	9 ppm
COHb Blood Concentration Thresholds of Concern	2.5%	2.0%

Source: Kleinman 2000, p. 3; EPA 2000, p. 1-5.

Recent Information Related to Children and CO

California SB 25 (1999) established a children's environmental health protection program. In response to SB 25, ARB is producing a series of pollutant-specific studies related to children, one of which covers CO (Kleinman 2000). ARB has created a web site for the program and the CO study is accessible from the web page: http://www.arb.ca.gov/ch/ceh/airstandards.htm. The Kleinman study shows that children experience 2.5% COHb with exposure to lower CO concentrations than adults. Kleinman's findings are summarized in Table 2.

Table 2. CO concentrations necessary to generate 2.5% COHb in children and adults.

Exposure Duration	Child at Rest	Adult at Rest
	Ambient CO Concentration (in ppm)	
1-hour average	26	33.5
8-hour average	8.4	9.3

Source: Kleinman 2000, p. 11.

Kleinman notes that more research is needed, and that "One might also hypothesize that children with asthma or other inflammatory lung diseases could require lower exposures to CO to reach target concentrations of 2.5% COHb because their baseline COHb levels might be elevated" (Kleinman 2000, p. 26).

The Kleinman work also cites potential dangers to fetal development if pregnant women are exposed to CO concentrations greater than 5.5 ppm (Kleinman 2000, p. 14). Note that the fetal development risks are related to exposures over a three-month averaging time (the last trimester of pregnancy) and would not be relevant to 8-hour hotspot concentration analyses. Kleinman also discusses potential dangers (including fetal death) of CO exposure during pregnancy due to acute, "high-level accidental" CO exposures (Kleinman 2000, pp. 23, 25). The findings are based largely on tobacco smoking literature and are probably not comparable to hotspot exposure analysis.

The U.S. Environmental Protection Agency's (EPA) June 2000 CO criteria document does not include a focused review of children's health effects. EPA notes that the subpopulation most at risk are heart disease patients that suffer exercise-induced angina (EPA 2000, p. 1-8). EPA cites one study in which asthmatics not taking corticosteroids to control their illness were found to have breath CO concentrations 3.8 times greater than healthy individuals; the study did not measure percent COHb, nor does EPA report what fraction of study participants were children (EPA 2000, p. 5-8).

EPA also cites potential concerns about the risks of CO exposure for fetal development. EPA cites longer-term exposure conditions (as opposed to hotspot exposure) that could lead to low birth weight (EPA 2000, p. 7-6).

Implications for Health Standards and Potentially Problematic California Areas

EPA had access to the same literature used by Kleinman, but declined to change the NAAQS for CO. Kleinman's CO review finds that children may, under some conditions, experience adverse health effects from CO exposure at concentrations less than the threshold needed for adult effects. The findings document that children need only be exposed for 8 hours to 8.4 ppm CO, rather than the 9.3 ppm CO necessary for adults, to experience %COHb levels associated with adverse effects (see Table 2). Asthmatic children may experience adverse effects at even lower concentrations than otherwise healthy children, although neither EPA (2000) nor Kleinman provide a threshold CO concentration level appropriate for asthmatic children. These findings may support ARB action to consider more stringent 1- and 8-hour CO state health standards.

With the exception of Los Angeles and Calexico, the maximum observed 8-hour CO concentrations in California are below the 8.4 ppm 8-hour threshold indicated in Table 2. During 1999 for example, the maximum 8-hour CO concentration observed outside of Los Angeles and Calexico was 7.8 ppm in the San Joaquin Valley (ARB 2001, Table A-15 p. 398). The 8.4 ppm threshold has not been exceeded (outside of Los Angeles and Calexico) since 1995 when the San Joaquin Valley experienced a 9.1 ppm peak 8-hour concentration.

Maximum 1-hour CO concentrations in California have not exceeded the 26 ppm 1-hour threshold in Table 2 since 1996, when Calexico experienced a 27 ppm 1-hour maximum (ARB 2001, Table A-14 p. 398).

Implications for Conformity CO Hotspot Analysis Requirements

If California were to reduce either or both of the 1-hour and 8-hour state CO health standards, it is possible that more stringent standards would not be exceeded outside of the Los Angeles and Calexico areas. There are no California areas that currently exceed the child-specific 1-hour thresholds cited by Kleinman in Table 2. Only Los Angeles and Calexico currently exceed the child-specific threshold for 8-hour CO in Table 2. The 8-hour child-specific threshold cited by Kleinman is quite close to the existing 8-hour CO NAAQS. It appears quite possible that even if the state were to create more stringent CO health standards, hotspot analyses could be appropriately required only on a case-by-case basis for problematic areas such as Los Angeles and Calexico. A final determination of the implications would need to be made after any changes to the standard were made.

References

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