Attachment A: Environmental and Health Consequences from Using Tires as Fuel; Health Risk Assessment[1]

[This attachment is taken from Ch. II-C (pp. II-45 to II-49) of my report to the Board: Schwartz, et. al., *Domestic Markets for California's Used and Waste Tires.*]

We present data about the emissions of pollutants from cement kilns burning tire/coal combinations, and information about possible health consequences and risk assessment methods.

1. California Test-Burn Results

Results of tests at four California cement kilns burning up to 20% tires (with two tests at one kiln) are summarized as follows (note that not all pollutant types were reported for all tests) (CIWMB, 1992, App. B; California Portland Cement, 1995; Carnot, 1996; RMC Lonestar, 1992; Bateman, 1996):

- *Dioxins and furans* showed increases of between 53% and 100% in four tests;
- *polycyclic aromatic hydrocarbons (PAHs)* increased in three tests (between 296% and 2230%) but decreased by 68% in a fourth test;
- *nitrogen oxide* (*NOx)* emissions increased by less than 10% at Kaiser Cement (Bateman, 1996), but decreased by 22% in two other tests;
- *sulfur oxides (SOx)* increased by 7.5% in one test, but decreased in two tests by 45% and 90%;
- *lead* emissions increased in three tests, by 59%, 388%, and 475%, respectively, and decreased in one test, by 94%;
- *hexavalent chromium* increased in one test by 727%, and decreased in two tests by 36% and 87%, respectively.

2. Canadian Test-Burn Results

A review of test-burning of tires at five Canadian cement kilns also showed a wide variation in emissions levels, similar to the results for California test burns. *Dioxins and furans* increased (when burning tires, compared to coal-only firing) by 37% and 247% in two of the tests, and decreased by 54% and 55% in the other two reported tests. Four of the five Canadian kilns experienced decreases in *nitrogen oxides (NOx)* ranging from 6% to 44%, while the a fifth had a 21% increase. Four tests reporting on *sulfur oxides (SOx)* showed increases of between 17% and 133%.

Both of the Canadian facilities that reported decreases in dioxins use the long, dry process in which whole tires are injected at the midsection of the kiln. The plant reporting the 247% increase in dioxins also reported an increase in NOx emissions. This facility uses the preheater process, and reportedly had been converted to burn whole tires that were injected into the preheater riser duct (the last and coolest combustion zone) (Proctor and Redfern, 1995).

While the data are insufficient to make definitive conclusions about the effects of process type and burn conditions on emissions, it does indicate that the way in which the tire fuel is introduced into the kiln may be important in maximizing combustion efficiency and minimizing toxic emissions levels.

3. NOx and SOx Emissions

The prospect of reducing NOx emissions by burning tires is appealing to cement kiln operators because the kiln's NOx emissions typically are close to the limits specified in operating permits (Flynn, 1995). Increases in NOx, as occurred at the Kaiser Cement facility, are viewed as "disappointing" (Bateman, 1996). Meeting SOx emissions limits has generally been less problematic for cement kiln operators because the raw

material from which cement is made acts as a "scrubber" to reduce sulfur below permit levels. Based on the material balance alone, we would expect higher SOx emissions from burning tires that contain sulfur levels higher than the low-sulfur coal the tires replace in California.[2] However, SOx increased in only one of the three California tests, although it increased in all four Canadian tests (Proctor and Redfern, 1995).

4. Chlorine Content and Dioxins

Public interest groups have long called for the regulation of burning wastes that contain chlorine because of their concern about resultant dioxin emissions. A content comparison indicates that tires may contain as much as two to five times the chlorine level of western coal, with an average of 0.04 weight percent for western coal, and a range of 0.07 to 0.2 weight percent for tires (CIWMB, 1992; 69). One major source of chlorine in tires is their halogenated butyl rubber liners. The addition of chlorine or bromine (the latter used more widely for truck tires) to the butyl rubber gives liners the air-impermeability required to maintain proper tire inflation.

5. Health Risk Assessment

California law (1987's "Air Toxics 'Hot Spots' Information and Assessment Act," AB 2588) requires owners or operators of facilities such as cement kilns to prepare a health risk assessment when applying for a permit to burn tires. The kiln operator's contractor uses the test-burn emissions results in risk assessment models to estimate the resulting changes in health risk due to burning tires along with coal, as compared to burning coal alone. Dispersion models predict ambient concentrations in populated areas near the facility; population exposure and risk of death are calculated from guidelines that contain risk factors.

The risk assessment must be reviewed by the state Office of Environmental Health Hazard Assessment (OEHHA) and approved by the local air pollution control district. If the district judges that potential significant health risks are associated with emissions from the facility, operators must notify all exposed individuals and must also reduce toxic emissions below the level of significance[2] (California Air Resources Board, 1994).

For tire-burning in cement kilns, the risk calculations have typically shown increases in risk that are still below the levels that local air pollution control districts consider "significant." However, opponents have not been convinced by determinations that risk is not significant, and point to important sources of uncertainty, some of which are acknowledged by kiln operators and risk assessors.

a. Uncertainties in risk assessment. Many uncertainties and potential sources for error exist in the risk assessments. The RMC Lonestar preliminary evaluation identified several "deficiencies" and "omissions" in the company's original risk assessment calculation (RMC Lonestar, 1992). Some of these error sources underestimated the risks from burning tires, whereas others caused risks to be overstated. One major source of underestimation of risk was a sampling error in formaldehyde emissions during coal-only firing; another source of underestimation was the omission of non-inhalation cancer risks arising from arsenic, cadmium and PCBs (RMC Lonestar, 1992). One staff member of the Bay Area Air Quality Management District indicated that some staff believe that the current risk assessment methodology is too conservative (i.e., it overstates risks), and he expects the basic methodology to be revised (Bateman, 1996).

Although some staff find the methodology too conservative, the document containing the risk assessment guidelines they use (issued by the California Air Pollution Control Officers Association [CAPCOA, 1993]), identifies important flaws in the methodology that lead to underestimating risks: 1) "Effects of exposure to more than one carcinogen or toxicant are also not quantified in the risk assessment. Many examples of additivity or synergism (effects greater than additive) are known" (CAPCOA, 1993; p. I-3). 2) "Additionally, there may be chemicals which pose health risks but are not considered in a given risk assessment for a number of reasons, including lack of information on toxicity" (CAPCOA, 1993; p. I-3). 3) "The estimates of cancer potency in humans contain many sources of uncertainty. . . . Differences in these factors . . . cannot be easily quantified and incorporated into risk assessment . . . . Other uncertainties arise in

the assumptions underlying the dose-response model used." (CAPCOA, 1993; p. I-4).

Other critics of risk assessment state that 1) risk assessment considers primarily the risk of death from cancer, but consequences other than death, such as disruption of human immune and hormone systems, can cause serious health, social, and economic damages (*Rachel's* #470, 1995); and, 2) models of cancer causation are controversial, and risk estimates can vary enormously depending on the model used (Ricci and Molton, 1986; pp. 85-86).

In addition to the specific sources of error cited above, the CAPCOA guidelines further state that because of the uncertainty inherent in risk assessment, risk numbers should be "used as a yardstick" and "should not be construed as the expected rates of disease in the exposed population" (CAPCOA, 1993; p. I-4). This statement implies that the specific risk number calculated by the risk assessments should not be compared to a criterion of "significant risk" as a basis for making decisions.

b. Recent evidence of health risks. The U.S. EPA's scientific advisory panel concluded that dioxins are more dangerous than previously believed and pose not only a risk of cancer but also a risk of disrupting reproductive processes (U.S. EPA, 1993). The Erice Statement, issued by an international group of scientists in November 1995, further warns of the serious threat posed by chemicals that disrupt human hormone systems. The statement says that research since 1991 has reinforced these concerns, and that "new evidence is especially worrisome because it underscores the exquisite sensitivity of the developing nervous system to chemical perturbations." Furthermore, according to the Erice statement, these chemical changes can undermine neurological and behavioral development of fetuses and infants, which could cause "reduced intellectual capacity and social adaptability, impaired responsiveness to environmental demands," or a variety of other functional problems. Compounding that threat, it continues, is the fact that many hormone-disrupting contaminants, even if less potent than natural products, occur in living tissue at concentrations millions of times higher than the natural hormones; and that humans and wildlife exhibit adverse health effects at existing environmental concentrations of synthetic chemicals that act as hormone disrupters (*Rachel's* #499, 1996). Thus, evidence exists that dioxins, furans, and PCBs disrupt hormone systems at extremely low levels, levels that are already found in human tissues. Furthermore, it is believed that there is no safe threshold below which disruption of the hormone system does not occur (Silbergeld, 1993).

Several recent studies have also shown that children exposed to relatively low levels of PCBs via their mothers' diets exhibited impairment of neurological and mental functioning that was correlated with the level of exposure (Jacobson and Jacobson 1996a and 1996b). This impairment occurred even though the mothers' PCB levels were within the normal range (i.e., there were no extreme exposures).

Notes: Attachment A

1. This attachment is taken from Ch. II-C (pp. II-45 to II-49) of my report to the Board: Schwartz, et. al., *Domestic Markets for California's Used and Waste Tires.*

2. A comparison of elemental analyses of tires with the coal the tires replace in California shows about twice the percentages (by weight) of sulfur in tires (CIWMB, 1992; 69).

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