Air Control Techniques, P.C.
301 East Durham Road
Cary, North Carolina 27513
Office (919) 460-7811
Fax (919) 460-7897

Sent via email: Ellen.Porter ellen@lmienviro.com

Ms. Ellen Porter
LMI Environmental
PO Box 2558, Roseburg, Oregon 97470
(541) 643-1748

Re: Suspension Burner Dioxin-Furan Emissions

Ellen,

As you requested, I have prepared some notes concerning the potential for tetra through octa-substituted dibenzo-*p*-dioxin and dibenzofuran ("dioxin-furans") emissions from wood-fired suspension burners. I understand that you will soon submit technical comments to the Oregon Department of Environmental Quality (ODEQ).

Based on my experience working in the dioxin-furan emission testing and emission control field for more than twenty years and the information summarized in this letter, I conclude that dioxin-furan emissions from this type of combustion system are at or close to negligible levels. Suspension burners should not be prioritized for detailed evaluation and testing of dioxin-furan emissions.

I have organized these comments into four subject areas: (1) characteristics of suspension burners, (2) characteristics, formation, and destruction of dioxin-furans, (3) thermal destruction of dioxin-furans in suspension burner gas streams, (4) more significant sources, and (5) summary.

1. Characteristics of Suspension Burners

These comments address wood-fired burners in which a finely divided wood fuel is burned in a combustion chamber without grates. The peak combustion chamber temperatures range from 800°C to 1,000°C. The fuel is finely divided and has a high surface area per unit mass of fuel. The fuel moisture content is a maximum of 15% by weight and is often in the range of 5% to 10% moisture. Accordingly, the time required for fuel drying and volatilization is quite short. The fuel quickly ignites and burns intensely with high flame temperatures. These units can be equipped with fabric filters to control the particulate matter emissions.

The combustion conditions in wood suspension burners are quite different from those in other wood-fired units such as spreader stokers, mass overfeed stokers, Dutch ovens, and pile burning. All of these other types of wood-firing equipment create conditions more favorable for dioxin-furan formation than suspension burners. Dioxin-furan emission factor data from these other types of combustion systems should not be applied to suspension burners. In fact, some caution is needed when reviewing most published literature concerning dioxin-furans, which is primarily oriented to studies of waste incineration processes having much different combustion conditions than suspension burners.

2. Characteristics of Dioxin-Furans

There is considerable variation in the dioxin-furan emission factors for major sources such as municipal waste incinerators, hazardous waste incinerators, medical waste incinerators, and sintering operations. Published data ranges from a high exceeding 40 ng TEQ/Nm^3 @ 7% O_2 to values less than 0.01 ng TEQ/Nm^3 @ 7% O_2. This large range approaching four orders of magnitude in emission concentrations is due primarily to the large number of factors that can affect the yield of dioxin-furans in combustion processes. Regulatory programs designed to protect public health should prioritize their efforts to those sources most vulnerable to high emission concentrations.

The emission concentrations of dioxin-furans from each source reflect the balance between the rate of formation and the rat of destruction in the combustion process and downstream air pollution control equipment. The formation mechanisms for dioxin-furan include the following:

- De Novo formation
- Catalytic reactions of metals and precursor organics on particle surfaces
- Gas phase homogeneous reactions
- Volatilization of native dioxin-furans from raw materials

A brief review of these four formation mechanisms demonstrates that wood-fired suspension burners lack all of the characteristics that favor dioxin-furan formation.

Of these four mechanisms, the De Novo reactions dominate. De Novo formation occurs in macro aromatic ring organics in a temperature range of 250-350^{o}C. It is generally reported that increased chloride content of the fuel increases the De Novo dioxin-furan yield; however, chlorine is not a limiting reactant in any combustion system. Oxygen levels above 1% are needed—a level that exists in all combustion processes. De Novo reactions occur primarily during smoldering of partially oxidized fuel. A suspension burner has no accumulated fuel bed that contain a smoldering carbonaceous material.

Reactions catalyzed primarily by copper, but also by iron, zinc, manganese, and aluminum occur at slightly higher temperatures. To be catalytically active, the metal must present on the surface of the ash particles. This is often the case in municipal, medical, hazardous waste incinerators, and sintering operations with high concentrations of metals in the waste feed. Wood dust has very low concentrations of these catalysts. The inorganic constituents of the wood fuel are also usually less than 2% by weight, far below the ash levels associated with wastes and other fuels.

The catalytic reactions primarily involve chlorinated precursor compounds such as chlorobenzene and chlorophenols. These partial oxidation products can be present in relatively low intensity combustion chambers such as the first one or two zones of a spreader stoker boiler, a Dutch oven, a backyard barrel burner, or a pile of agricultural waste. In the intense combustion of a suspension burner these organic precursors are destroyed during exposure to temperatures hundreds of degrees Fahrenheit above their autoignition temperatures. These precursors are not available to participate in surface-controlled catalytic reactions.

The same organic precursors that can participate in surface-controlled catalytic conversion can also react homogeneously in combustion gas streams to form dioxin and to a lesser extent furan compounds. However, the congener concentration pattern expected from these gas phase reactions are rarely observed. Accordingly, this is not considered a major reaction mechanism. The lack of these organic precursors in the combustion gas streams of suspension burners also severely limits this possible formation mechanism.

The fourth formation mechanism is the volatilization of dioxin-furans from raw materials during the drying and volatilizing stage of combustion processes. This mechanism can be a contributor to dioxin-furan emissions from some waste incinerator and cement kiln systems. However, native dioxin-furan concentrations in wood are probably extremely low.

For all of these reactions, the formation of significant dioxin-furan emission concentrations in suspension burners is expected to be very low.

3. Thermal Destruction of Dioxin-Furans

As stated earlier, the emission concentrations of dioxin-furans are the result of competing formation and destruction reactions.

The auto-ignition temperatures of all dioxin-furan congeners are in the range of 600°C to 700°C. At temperatures 100°C above these levels, any dioxin-furan compounds formed in a combustion process are rapidly destroyed. For example, the data compiled by Dellinger et. al. indicates very high dioxin-furan destruction at the peak combustion chamber temperature range typical of suspension burners.

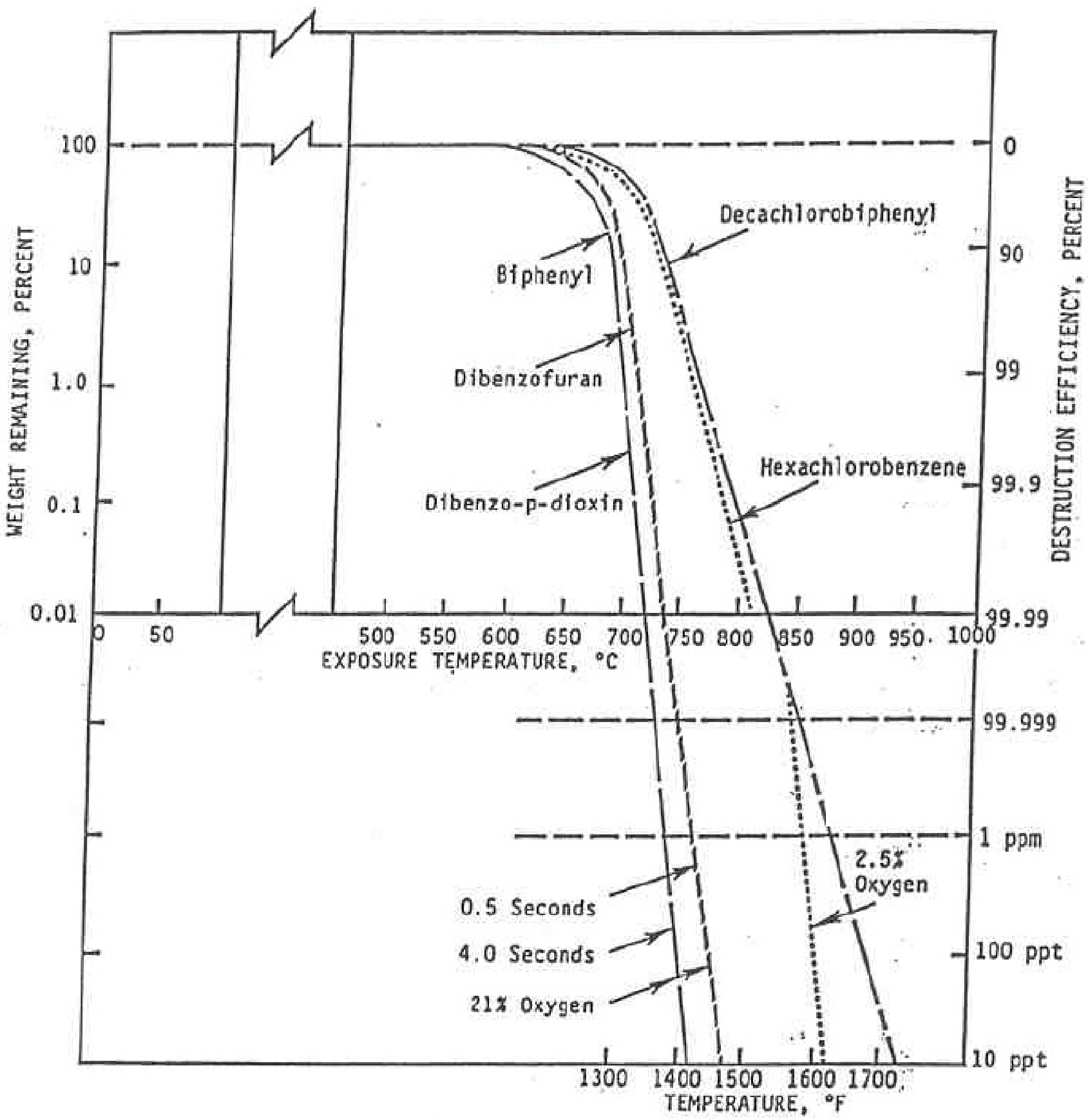

Figure 1. Destruction Efficiency of Dioxin-Furans
Dellinger, B. Sidhu, S, Rubey, S. Shanbag, and R. Striebich, University of Dayton, 1995

Due to the high flame and combustion chamber temperatures, little if any of the dioxin-furans formed in the combustion chamber would survive. Even if there were some chlorides, metals, wood preservatives, and/or pesticide contamination in the wood fuel fired in a suspension burner, the dioxin-furans initially formed would be destroyed before exiting the combustion chamber.

4. More Significant Sources

An excellent summary of the dioxin-furan emission rates from a wide variety of industrial, agricultural, community sources, and natural sources is provided in the article by Zhang et. al. This article indicates that dioxin-furan emission concentrations from some agricultural, community, and natural sources are several orders of magnitude higher than those from some wood-fired boilers, and especially higher than the negligible levels anticipated from suspension burners. These agricultural, community, and natural sources are especially consequently considering that the dioxin-furans can deposit in home gardens and in farm fields, where the dioxin-furans can enter the food chain—the most significant route of human exposure. Dioxin-furans can concentrate in the food chain.

If public health concerns are driving the interest in dioxin-furan emissions, then resources should be prioritized for these categories of sources with much high emissions and much greater potential exposure impact. These sources include, but are not limited to agricultural burning, construction-related burning, and back yard waste barrel burning.

5. Summary

In summary, the rate of dioxin-furan formation in wood-fired suspension burners are low due to the lack of reactants important in the formation reactions. The rate of dioxin-furan destruction at the peak combustion temperatures of suspension burners are quite high. The resulting emissions of dioxin-furans from suspension burners are expected to be at or close to negligible levels.

I hope that these comments are helpful in evaluating dioxin-furan emissions from suspension burners.

Regards,

John Richards, Ph.D., P.E.
Air Control Techniques, P.C.

References

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