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Project Summary

Air Emissions from Scrap Tire Combustion

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Two to three billion (2-3x10[9]) scrap tires are in landfills and stockpiles across the United States, and approximately one scrap tire per person is generated every year. Scrap tires represent both a disposal problem and a resource opportunity (e.g., as a fuel and in other applications). Of the many potential negative environmental and health impacts normally associated with scrap tire piles, the present study focuses on (1) examining air emissions related to open tire fires and their potential health impacts, and (2) reporting on emissions data from well designed combustors that have used tires as a fuel.

This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Air emissions from two types of scrap tire combustion are addressed: uncontrolled and controlled. Uncontrolled sources are open tire fires, which produce many unhealthful products of incomplete combustion and release them directly into the atmosphere. Controlled combustion sources (combustors) are, for example, boilers and kilns specifically designed for efficient combustion of solid fuel. Combustor emissions are much lower and more often than not, these sources also have appropriate add-on air pollution control equipment for the control of particulate emissions.

Very little data exist for devices that use scrap tires for fuel, but are not well-designed. These sources include fireplaces, wood stoves, small kilns, small incinerators, or any device with poor combustion characteristics. Air emissions from these types of devices are likely between that of open burning and a combustor. However, there is serious concern that the emissions are much more similar to those of an open tire fire than a combustor.

Open Tire Fires

Air emissions from open tire fires have been shown to be more toxic, (i.e., mutagenic) than those of a combustor, regardless of the fuel. Open tire fire emissions include "criteria" pollutants, such as particulates, carbon monoxide (CO), sulfur oxides (SO_x), oxides of nitrogen (NO_x), and volatile organic compounds (VOCs). They also include "non-criteria" hazardous air pollutants (HAPs), such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs), arsenic, cadmium, nickel, zinc, mercury, chromium, and vanadium. Both criteria and HAP emissions from an open tire fire can represent significant acute (short-term) and chronic (long-term) health hazards to firefighters and nearby residents. Depending on the length and degree of exposure, these health effects could include irritation of the skin, eyes, and mucous membranes, respiratory effects, central nervous system depression, and cancer. Firefighters and others working near a large tire fire should be equipped with respirators and dermal protection. Unprotected exposure to the visible smoke plume should be avoided.

Data from a laboratory test program on uncontrolled burning of tire pieces and ambient monitoring at open tire fires are presented and the emissions are characterized. Mutagenic emission data from open burning of scrap tires are compared to other types of fuel combustion. Open tire fire emissions are estimated to be 16 times more mutagenic than residential wood combustion in a fireplace, and 13,000 times more mutagenic than coal-fired utility emissions with good combustion efficiency and add-on controls.

Table 1 lists 34 target compounds representing the highest potential for inhalation health impacts from open tire fires. The list was developed by analyzing laboratory test data and open tire fire data collected at nine tire fires. The list can be used to design an air monitoring plan in order to evaluate the potential for health risks in future events.

Methods for preventing and managing tire fires are presented. Recommendations are presented for storage site design, civilian evacuation, and fire suppression tactics. For example, tire piles should not exceed 6 m (20 ft.) in height; maximum outside dimensions should be limited to 76 m (250 ft.) by 6 m (20 ft.). Interior fire breaks should be at least 18 m (60 ft.) wide. Civilians should be evacuated when they may be subject to exposure by the smoke plume. Fire suppression tactics are site and incident-specific and firefighters should have specialized training to deal effectively with them.

Other Impacts from Open Tire Burning

The scope of this report is limited to airborne emissions. However, significant amounts of liquids and solids containing dangerous chemicals can be generated by melting tires. These products can pollute soil, surface water, and ground water and care must be taken to properly manage these impacts as well.

Controlled Combustion

The results of a laboratory test program on controlled burning of tire-derived fuel (TDF) in a Rotary Kiln Incinerator Simulator (RKIS) are presented. Natural gas was the primary fuel, supplemented by TDF. In all, 30 test conditions were run, with the TDF feed rate varying from 0 to 21.4% of heat input. The test conditions were achieved by varying kiln firing rate, combustion air flow rate, and tire feed rate. The majority of the tests were conducted with a steady-state feed of TDF. However, variations in the mode of TDF feeding were simulated in two tests to evaluate the impact of transient operation on air emissions.

Based on the results of the RKIS test program, it was concluded that, with the exception of zinc emissions, potential emissions from TDF are not expected to be very much different than from other conventional fossil fuels, as long as combustion occurs in a well-designed, well-operated and well-maintained combustion device. However, as with most solid fuel combustors, an appropriate particulate control device would likely be needed in order to obtain an operating permit in most jurisdictions in the U.S.

Test data from 22 industrial facilities that have used TDF are presented: 3 kilns (2 cement and 1 lime) and 19 boilers (utility, pulp and paper, and general industrial applications). All sources had some type of particulate control. A summary of criteria emissions data from seven utility boilers that have burned various amounts of TDF in addition to their main fuel supply is presented in Table 2. In general, the results indicate that properly designed existing solid fuel combustors can supplement their normal fuels, which typically consist of coal, wood, coke, and various combinations thereof, with 10 to 20% TDF and still satisfy environmental compliance emissions limits. Furthermore, results from a dedicated tires-to-energy (100% TDF) facility indicate that it is possible to have emissions much lower than produced by existing solid-fuel-fired boilers (on a heat input basis) with a specially designed combustor and add-on controls.

Depending on the design of the combustion device, some tire processing is usually necessary before it is ready to be used as a fuel. Processing includes dewiring and shredding and/or other sizing techniques. Some specially designed boilers and cement kilns have had their feed systems designed to accept whole tires.

Conclusion

Air emissions have been documented from open burning of scrap tires and from TDF in well-designed combustors. Laboratory and field studies have confirmed that open burning produces toxic gases that can represent significant acute and chronic health hazards. However, field studies have also confirmed that TDF can be used successfully as a 10 - 20% supplementary fuel in properly designed solid-fuel combustors with good combustion control and add-on particulate controls, such as electrostatic precipitators or fabric filters. Furthermore, a dedicated tire-to-energy facility specifically designed to burn TDF as its only fuel has been demonstrated to achieve emission rates much lower than most solid fuel combustors.

No field data were available for well-designed combustors with no add-on particulate controls. Laboratory testing of an RKIS indicated that efficient combustion of supplementary TDF can destroy many volatile and semi-volatile air contaminants. However, it is not likely that a solid fuel combustor without add-on particulate controls could satisfy air emission regulatory requirements in the U.S.

No data were available for poorly designed or primitive combustion devices with no add-on controls. Air emissions from these types of devices would depend on design, fuel type, method of feeding, and other parameters. There is serious concern that emissions would be more like those of an open tire fire than a well-designed combustor; however, emissions testing would have to be conducted to confirm this.

Table 1. Target Compounds by Criteria

Target Compound	*Criteria*			
	CA	*TLV*	*Subchronic RfC*	*Chronic RfC*
Acenaphthene	*X*			
Acenaphthylene	*X*			
Arsenic	*X*			
Barium				*X*
Benz(a)anthracene	*X*			
Benzene	*X*			
Benzo(a)pyrene	*X*			
Benzo(b)fluoranthene	*X*			
Benzyl chloride	*X*			
Butadiene	*X*			
Carbon Monoxide		*X*		
Carbon Tetrachloride	*X*			
Chloroform	*X*			
Chromium	*X*			
Chrysene	*X*			
Coal Tar Pitch	*X*	*X*		
Cumene			*X*	*X*
Dibenz(a,h)anthracene	*X*			
1,2-Dichloropropane	*X*		*X*	*X*
Dibenz(a,h)anthracene	*X*			
Ethylene Dichloride	*X*			
Hexachloroethane	*X*			
Hexane			*X*	*X*
Lead	*X*			
Methylene Chloride	*X*			
Nickel	*X*			
Phenol	*X*			
Styrene	*X*			*X*
Sulfur Dioxide		*X*		
Sulfuric Acid		*X*		*X*
Toluene (Methyl Benzene)			*X*	*X*
1,1,2-Trichloroethane	*X*			
Trichloroethylene	*X*			
Vanadium		*X*		
Xylene, o		*X*		

CA = Suspected or Confirmed Human Carcinogen.
TLV = Reported Value is 33% of Threshold Limit Value.
RfC = Inhalation Reference Concentration.

Table 2. Summary of Criteria Pollutant Emission Data at Utilities Using TDF

Power Plant	Particulates (Total)		Sulfur Oxides		Nitrogen Oxides		Carbon Monoxide	
	g/MJ	lb/MMBTU	g/MJ	lb/MMBTU	g/MJ	lb/MMBTU	g/MJ	lb/MMBTU
Facility A								
100% Tires	9.5×10^{-7}	2.2×10^{-6}	6.0×10^{-6}	1.4×10^{-5}	4.2×10^{-5}	9.8×10^{-5}	3.1×10^{-5}	7.2×10^{-5}
Facility B (Coal)								
0% TDF	0.09	0.21	0.606	1.41	0.34	0.78	NT	NT
5% TDF	0.0064	0.015	0.774	1.8	0.25	0.58	NT	NT
10% TDF	0.004	0.009	0.658	1.53	0.13	0.3	NT	NT
Facility C (Coal)								
0% TDF	0.22	0.52	0.49	1.14	0.34	0.79	0.65	1.52
7% TDF	0.06	0.14	0.37	0.87	0.39	0.91	3.12	7.26
Facility D (Coal)								
0% TDF	0.027	0.063	2.28	5.3	0.258	0.601	NT	NT
5% TDF	0.031	0.0717	2.46	5.73	0.219	0.51	NT	NT
10% TDF	0.0242	0.0564	2.46	5.71	0.188	0.436	NT	NT
15% TDF	0.035	0.0815	2.35	5.47	0.191	0.443	NT	NT
20% TDF	0.0195	0.0453	2.3	5.34	0.166	0.387	NT	NT
Facility E (Wood)								
0% TDF	0.036	0.083	0.009	0.021	0.009	0.021	NT	NT
7% TDF	0.133	0.31	0.032	0.074	0.054	0.125	NT	NT
Facility F (Coal)								
2% TDF	0.073	0.17	2.49	5.78	NT	NT	NT	NT

NT = Not tested or data not available.
Note: Above data taken directly from reference; no adjustment was made to significant digits.

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***Paul M. Lemieux** is the EPA Project Officer (see below).*
The complete report, entitled "Air Emissions from Scrap Tire Combustion," (Order No. PB98-111701; Cost: $28.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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The EPA Project Officer can be contacted at:
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