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## Book of Abstracts
## November 2-5, 1998

Kellie Ann Beall, Editor

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

**United States Department of Commerce**
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**U.S. Department of Commerce**
William M. Daley, *Secretary*
**Technology Administration**
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# SIMULATION OF LARGE INDUSTRIAL OUTDOOR FIRES

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Large outdoor fires can be conveniently divided into two categories based on the fuel source. Wildland fires are characterized by a relatively low heat release rate per unit area of ground covered by fuel, but a very large area over which the fire can spread. Indeed, the description of the fire spread process is an essential part of any successful simulation of such an event. Industrial fires, in contrast, are usually more highly localized but intense emitters of heat, smoke, and other combustion products. This is particularly true if the fuel is a petroleum based substance, with a high energy density and sooting potential. This latter type of fire is the object of study in the present paper.

The hazards associated with such fires occur on two widely separated length scales. Near the fire, over distances comparable to the flame length, the radiant energy flux can be sufficiently high to threaten both the structural integrity of neighboring buildings, and the physical safety of firefighters and plant personnel. At much greater distances, typically several times the plume stabilization height in the atmosphere, the smoke and gaseous products generated by the fire can reach the ground in concentrations that may be unacceptable for environmental reasons. The far field hazard has been studied previously by the present authors [1], [2]. This work has led to the development of a computer code ALOFT, which is available from NIST. A comprehensive description of ALOFT and its generalizations to complex terrain can be found in [3].

In this paper the near field hazard associated with the flame radiation is studied. The scenario chosen is a fire on top of an oil storage tank adjacent to several neighboring tanks. This scenario is chosen both for its intrinsic importance and because it illustrates the ingredients needed to generate a realistic simulation of such an event. The heat release generated by a fire on this scale can reach several gigawatts if the entire pool surface is exposed and burning. Such fires interact strongly with the local topography (both natural and man made) and the vertical distribution of wind and temperature in the atmosphere. Moreover, the phenomena are inherently time dependent and involve a wide temperature range. Thus, the simplifications employed in ALOFT and its generalizations can not be used in the present analysis.

A mathematical model is presented that contains the basic components needed to address this problem. The model consists of a version of the authors three dimensional enclosure fire model [4], [5] modified to account for a stratified atmosphere. This is supplemented by a simple radiative tranport model that ignores the absorption by the smoke generated in the fire. The effect of the absorption is accounted for by lowering the radiant energy emission from the flames. The wind in the atmospheric boundary layer is represented by a power law velocity profile and the ambient temperature fields are taken to be isothermal. The storage tank farm is represented by a 3x3 array of identical tanks 84 meters in diameter and 27 meters high. Each tank sits in a 9 meter deep trench arranged so that the spacing between tank centers is two tank diameters. The surrounding terrain is flat. The computational domain is a cube 3/4 kilometer on a side. This geometry is an idealization of a portion of an oil storage facility in Tomakomai, Japan.

Two simulations will be discussed, showing an upwind and a centrally located tank top fire. The plume dynamics, velocity, and radiant heat flux incident on the tank surfaces will be shown. The implications of these results for both storage tank safety and the utility of this methodology in general will be considered. The examples illustrate the complex interaction between the topography, the ambient atmosphere, and the fire scenario. Even for the relatively simple configuration chosen for study here, there are many factors that strongly affect the resulting fire dynamics. The ambient wind and temperature fields play at least as significant a role as they do in the downwind smoke dispersion described by the ALOFT code. The presence of natural topographical features in the vicinity of the storage tanks would further modify the flow patterns, and hence the radiation fields. Finally, the absorption of thermal radiation by the smoke and gaseous combustion products will alter the plume structure by creating distributed energy sources in the flow field.

Rather than arbitrarily choosing topograpical, structural, and meteorological features to simulate, it would seem to make more sense to couple this emerging simulation capability to databases that describe the actual built environment and associated topography. Similarly, arbitrary prescriptions of the ambient atmosphere could be replaced with local meteorology simulations based on databases and computer models in use by the weather prediction community. The result would be a simulation capability that could be used routinely to predict the fire hazards resulting from natural or man made disasters in the real world.

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