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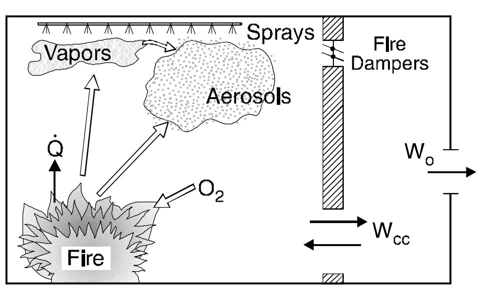
FIRE HAZARDS ANALYSIS

Industrial, chemical and process facilities periodically handle process or waste materials, whose loss of confinement could result in a fire, explosion or toxic release. Facilities which handle these types of materials are designed to respond to an accident, mitigate its consequences, and preclude any external release. Design features such as wet sprays, dry chemical sprays, fire dampers, and HVAC operations attempt to control the release of any hazardous materials. To determine the effectiveness of these design features, it is necessary to assess the rates of release of heat, gases and aerosols from the accident and quantify the transport and deposition of the energy, gases and aerosols throughout the structure and environment. This type of assessment allows for a determination of what is important towards mitigating the event and defines the timing of key events. An often used approach is to assume the entire inventory of the combustion products is released from the facility and the consequence of this release is determined. Although this provides for a bounding assessment, it does not allow for review of the facilities mitigating capabilities.



The above figure represents a two room configuration recently analyzed by FAI. Given a hazardous material fire in one room, products of the fire will include aerosols such as smoke or other hazardous particulates, and vapors, as well as heat. An aerosol is a system of fine solid or liquid particles in gaseous suspension. Pressure and temperature variations allow transport of this gaseous media throughout the facility and potentially external to the facility. It is therefore important when analyzing accidents to quantify the mass of suspended aerosols during the accident. Aerosols are removed through natural mechanisms which include gravitational sedimentation, inertial impaction and others. Considering these removal mechanisms as well as the source, the total suspended aerosol mass is given by

$$\frac{dm}{dt} = -\lambda m + s + \sum W_i C_i$$

where m represents the mass of aerosol, 8 the aerosol settling rate, s the source of aerosol production, W_i the flow rate and C_i the aerosol concentration. A key factor when making such assessments is the flow rate between rooms. Typically the differential pressure between rooms may be small and not reflective of a significant flow rate, however, the temperature difference between rooms may be significant to drive a counter-current flow between rooms. This counter-current flow can supply oxygen to the fire and provide a flow path for distribution of aerosol products.

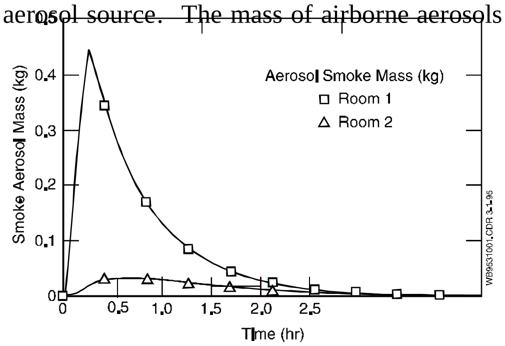
Aerosol production and transport were studied for the two-room configuration shown in the figure. A postulated accident released methanol which came in contact with an oxidizing agent. The stoichiometric reaction for combustion of methanol is

$$CH_3OH + 3/2\, O_2 \Rightarrow CO_2 + 2H_2O + Q_{methanol}$$

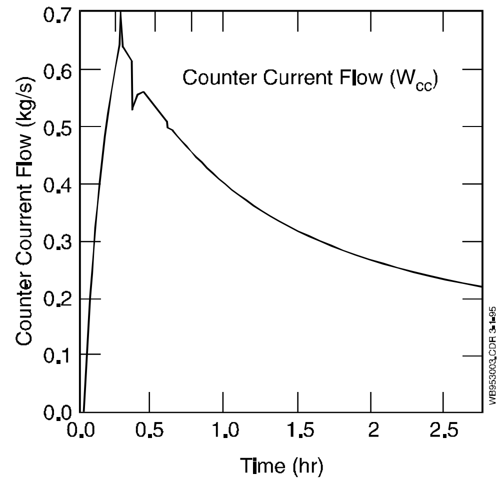
The burning methanol ignited cellulose, i.e., paper and paper byproducts, releasing heat and aerosols. Eventually the ceiling temperature reached the setpoint value and sprays were initiated which then put out the fire. The timing of spray operation is important since it eliminates the aerosol source and allows for the gradual reduction in the airborne mass.

Aerosol production is shown in the first plot. The mass of aerosols grow until approximately

16 minutes into the fire. At this point the wet sprays suppressed the fire and eliminated the aerosol source. The mass of airborne aerosols



begins to decrease through the mechanisms discussed earlier. This figure also shows that aerosols are carried into the second room through counter current flow. The second plot shows that the counter current flow increases as the fire heats the first room, and decreases as the temperature difference between the two rooms decreases. The room cooling effect of the fire sprays leads to a reduction in the density differences and thus the counter current flow.



Spray operation resulted in a reduction of the aerosol source and the counter current flow. The final result was a reduction in the release of potentially hazardous material.

The two-room analyses was performed using the GCA code developed by FAI. The case study was eventually expanded to include four rooms and the operation of HVAC systems between the rooms. The result was an understanding of the fire propagation and the effect various systems had on this propagation.

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