Abstract Submitted
for the DFD05 Meeting of
The American Physical Society

Development and ignition of a strong under-expanded jet MATEI RADULESCU, CHUNG K. LAW, Princeton University — The high pressure storage of a combustible gas presents several explosion hazards in the case of an accidental tank rupture or puncture. Although the establishment and ignition of a steady jet was studied extensively in the past, the starting process has attracted much less attention. In the present study, we focus on the initial transient accidental release of a light combustible gas from a tank at high initial pressure. When the gas is light, such hydrogen, a strong hemi-spherical blast wave is driven in the surrounding air, compressing the air to high temperatures. The hot air exchanges mass and heat with the cold expanded hydrogen at the jet head interface via diffusion and can lead to local ignition. Simulations of the non-reactive release of under-expanded jets are used to elucidate the transient gas-dynamics of the jet establishment, involving the decay of the hemispherical shock and contact surface and the establishment of the barrel shock system of steady under-expanded jets. The results are used to validate a semi-empirical theory for the time history profiles of shock and contact surface decay. The ignition problem is treated separately from the gasdynamics problem as a non-steady diffusion layer, where the evolution of the diffusion layer is given analytically. Estimates of the critical tank pressures and jet sizes are derived for conditions at which a diffusion layer will be ignited.

Matei Radulescu
Princeton University

Date submitted: 12 Aug 2005 Electronic form version 1.4