Impact of Vapor Cloud Detonation Propagation from a Congested Area on Building Blast Loads

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The potential for a deflagration to detonation transition (DDT) to occur in an unconfined vapor cloud explosion (VCE) with high reactivity flammable gases (e.g., ethylene, hydrogen, etc.) under conditions relevant to chemical processing and petroleum refining plants has been demonstrated in multiple test programs. Tests have also shown that a vapor cloud detonation will readily propagate from a congested volume into an open (i.e., uncongested) area. For comparatively small flammable gas clouds which are contained within a congested volume (e.g., a process unit), the VCE blast loads away from the cloud are similar whether the VCE occurs as a high speed deflagration or a detonation, although the loads in and near the cloud are much higher with a detonation. However, the blast loading from these two types of VCEs can be very different in the case of a large gas cloud extending well outside the congested volume. With a deflagration, the flame front velocity will decrease rapidly outside the congested volume such that the portion of the flammable gas cloud outside the congested volume contributes little to the resulting blast load. In contrast, a detonation wave will propagate through the portion of the flammable gas cloud outside the congested volume, increasing the explosion energy and decreasing the standoff to targets away from the congested volume.

The focus of this paper is on the impact of the vapor cloud detonation propagation into an uncongested area on the resulting blast load to buildings in the surrounding area. Test data relevant to high reactivity DDTs and detonation wave propagation are briefly reviewed. A series of parametric analyses are presented which illustrate the impact of the detonation wave propagation on the building blast loads at a range of standoffs and orientations relative to the release direction. Release cases were run for several high-reactivity fuels over a range of release conditions and hole sizes. The impact on the resulting blast load is large for flammable clouds which extend well beyond the congested volume.