A study on the Effect of Trees on Gas Explosions

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Abstract

The downstream as well as the upstream oil and gas industry has for a number of years been aware of the potential for flame acceleration and overpressure generation due to obstacles in gas clouds caused by leaks of flammable substances. To a large extent the obstacles were mainly considered to be equipment, piping, structure etc. typically found in many installations. For landbased installations there may however also be a potential for flame acceleration in regions of vegetation (like trees and bushes). Vegetation may be contributing to overpressure generation or may even be the main source for overpressure. The present paper summarizes a study into the effects of vegetation. The study contains both a numerical and an experimental part and was performed in the period 2006-2008.

The numerical analysis consisted of modelling a site containing hydrocarbons and the surrounding area with FLACS. The site itself was not significantly congested and it was not expected to give rise to high overpressures in case of a hydrocarbon leak. However, alongside the roads surrounding the site, dense vegetation in the form of trees and bushes was included. A large, shallow, heavier-than-air gas cloud was defined to cover part of the site and surroundings. Upon ignition a flame was established in the gas cloud. This flame accelerated through the trees along the surrounding roads, and resulted in high overpressures of several barg being generated. This is to the authors' knowledge the first time the effect of trees on explosions has been demonstrated by 3D analyses.

As a consequence of these results, and since the software had been validated against typical industrial congestion rather than dense vegetation, a set of experiments to try to demonstrate if these effects were physical was carried out as well. The test volume consisted of a plastic tunnel, 20 m long with a semi-circular cross-section 3.2 m in diameter allowing for representing lanes of vegetation. The total volume of the tent was approximately 80.4 m³. The experimental programme involved different degrees of vegetation size, vegetation density (blocking ratio) and number of vegetation lanes (over the full length of the tunnel). The experiments were performed with stoichiometric propane-air mixtures resulting in continuously accelerating flames over the full length of the tunnel for some of the scenarios investigated. The maximum flame speeds seen were in the order of 50-60 m/s.

The main conclusions of the study are that trees can have an influence on flame acceleration in gas-air clouds, and that advanced models such as FLACS can be used to study such influence. More research is needed, however, because even if FLACS predicts flame acceleration in dense vegetation, no evidence exists that applying the code to trees rather than rigid obstacles provides results of acceptable accuracy.