Abstract

Many accidents involve two-phase releases of hazardous chemicals into the atmosphere. Rainout results in reduced concentrations in the remaining cloud, but can also lead to extended cloud duration because of re-evaporation of the rained-out liquid. For accurate hazard assessment one must accurately predict both the amount of rainout and re-evaporation of the pool.

This paper describes the results of a third phase of a Joint Industry Project (JIP) on liquid jets and two-phase droplet dispersion. The aim of the project is to increase the understanding of the behaviour of sub-cooled (non-flashing) or superheated (flashing) liquid jets, and to improve the prediction of droplet atomisation, droplet dispersion and rainout. Phase II of the JIP was limited to scaled experiments for water with initial droplet-size data measured at a single value of the superheat only. Furthermore the modelling simplistically assumed one single averaged droplet size (Sauter Mean Diameter, SMD) with rainout at a single point only. As a result Phase III was started to account for these issues.

The first stage of Phase III included scaled experiments for water, gasoline, cyclohexane, butane and propane for a range of superheats (carried out at Cardiff University). It provided recommendations for atomisation correlations in the regimes of mechanical break-up, transition to flashing, and fully flashing, and the tri-functional modelling approach previously proposed in Phase II of the JIP was endorsed. See the companion paper II for further details.

The second stage of Phase III included large-scale butane experiments carried out by INERIS to ensure that for more realistic scenarios the derived droplet size correlations are accurate. See the companion paper III for further details.

The third stage of Phase III included model validation and model improvements carried out by DNV Software, including validation of release rate and initial droplet size against the above scaled and large-scale experiments. New refined correlations for droplet size correlation and SMD were formulated and implemented into the Phast discharge model. It was compared against a range of other droplet size and rainout correlations published in the literature, in conjunction with validation against an extensive set of experiments. It was shown that the new droplet size correlation generally performs better against experimental data than the selected existing correlations.

To further improve the rainout prediction, the Phast dispersion model (UDM) was extended to allow simultaneous modelling of a range of droplet sizes and distributed rainout (rather than rainout at one point). It also included further improvements to pool and dispersion modelling after rainout, and validation for dispersion from LNG and LPG pools.