Shell Global Solutions

HYDROGEN RELEASES IGNITED IN A SIMULATED VEHICLE REFUELLING ENVIRONMENT

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INTRODUCTION

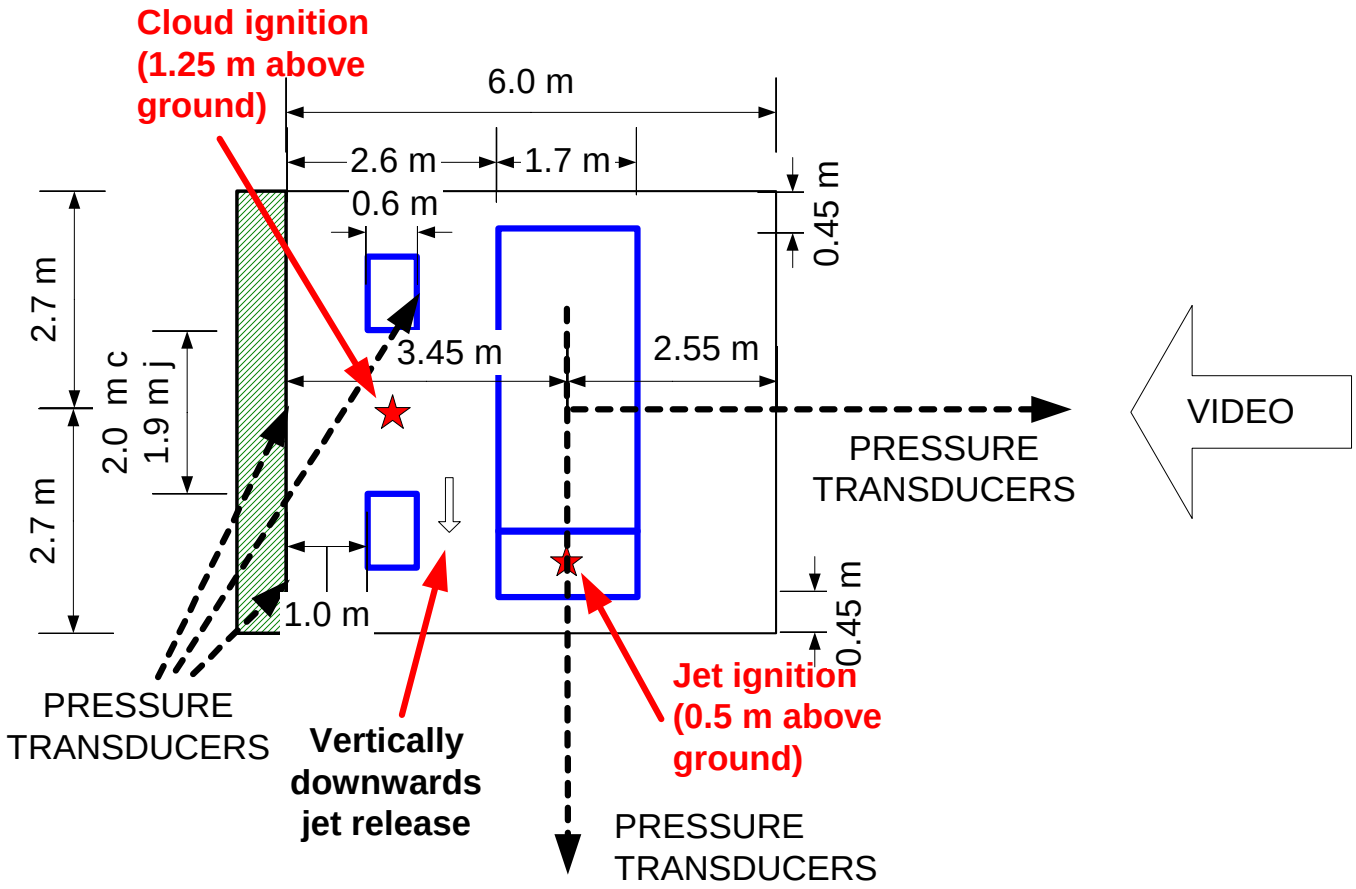
To gain a better understanding of the potential explosion hazard consequences associated with high-pressure leaks from hydrogen refuelling systems Shell Hydrogen initiated an industry funded study.

The objectives were to quantify the explosion hazard consequences in a refuelling environment for the ‘worst case’ condition of a premixed gas cloud as well as simulations of actual high-pressure leaks.

This paper describes two of the experiments from this study to allow comparison with results from modelling studies within HySafe and HyApproval.

REFUELLING STATION CONGESTION

EXPERIMENTAL ARRANGEMENT



EXPERIMENTAL ARRANGEMENT
Jet release rig

EXPERIMENTAL ARRANGEMENT
Pre-mixed cloud rig

RELEASE CONDITIONS
Pre-mixed trials

Cloud volume: 70.16 m^3

Gas mixture temperature: 28.9 ^oC

Relative humidity: 42.1 %

Ignition position: between dispensers

Equivalence ratio of mixture on ignition: 1.09

Mass of hydrogen ignited: 1.847 kg

RELEASE CONDITIONS
Jet release trials

Storage vessel and pipe volume: 0.252 m^3

Initial vessel pressure: 40.17 MPa

Initial vessel temperature: 289.4 K

Release orifice diameter: 8 mm

Release position: downwards between dispenser and ‘engine’ bay

Ignition position: within ‘engine’ bay

RELEASE CONDITIONS
Jet release trials

Time of spark after release: 0.7 s (shortest delay)

Nozzle pressure on sparking: 27.91 MPa

Flow rate on sparking: 0.93 kg/s

Mass released on sparking: 0.587 kg

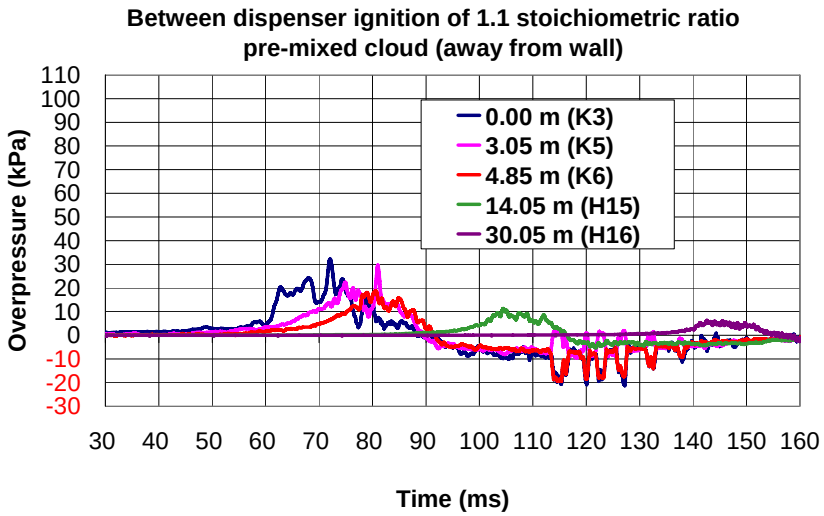
Total mass released: 2.097 kg

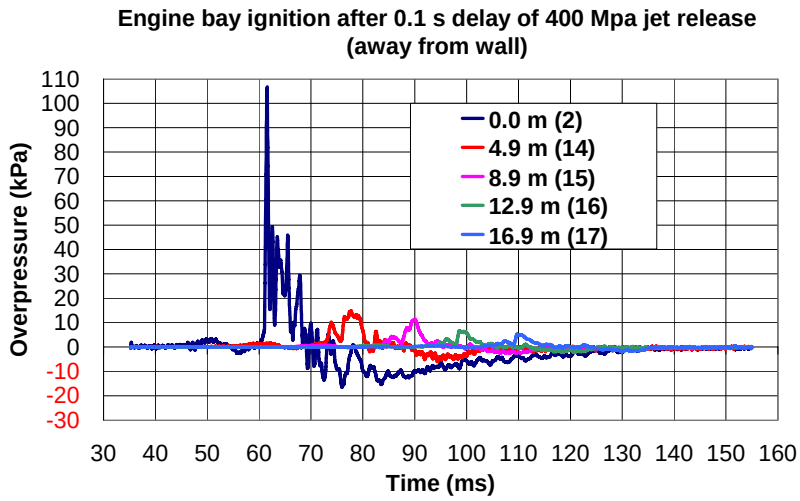
COMPARISION OF RESULTS

Both after 80ms (2nd frame after ignition)

COMPARISION OF RESULTS

Pressure traces measured away from the wall



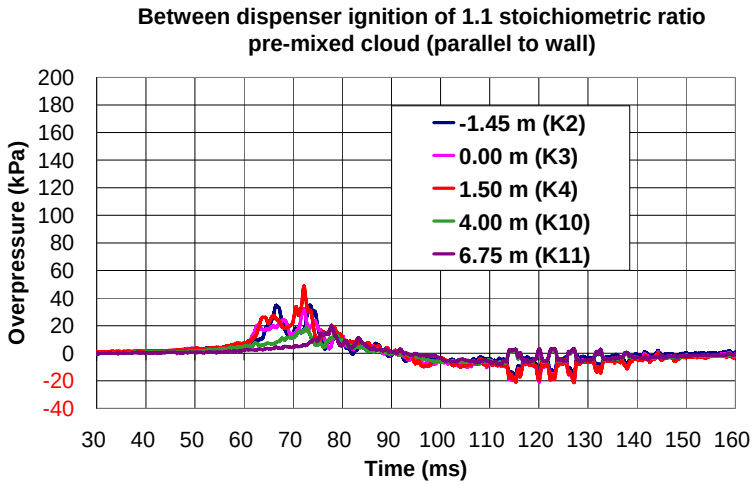


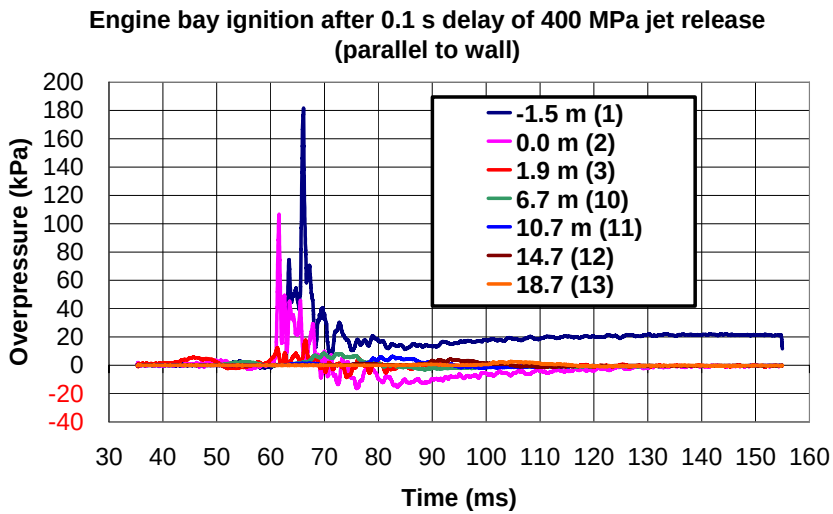
Pre-mixed cloud trial

40 MPa jet release trial

COMPARISION OF RESULTS

Pressure traces measured parallel to wall

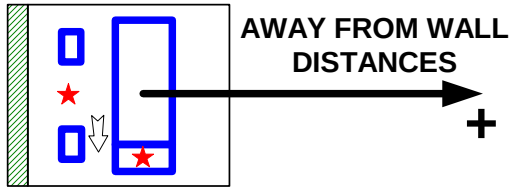


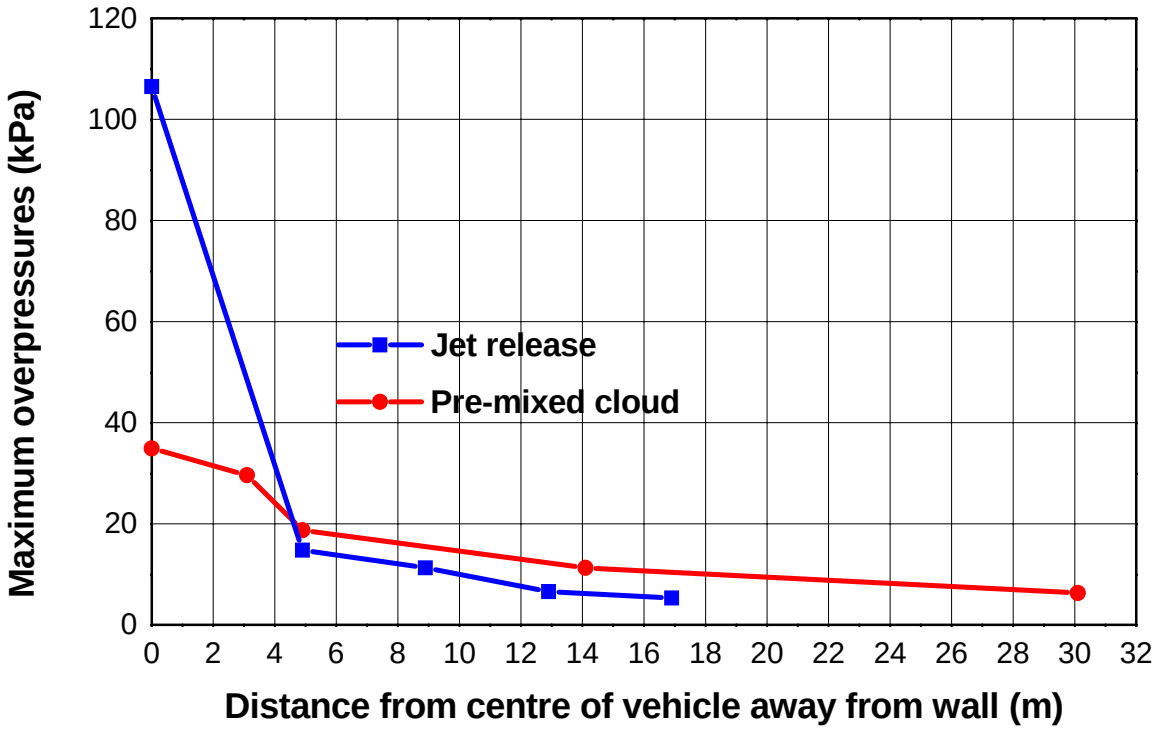


Pre-mixed cloud trial

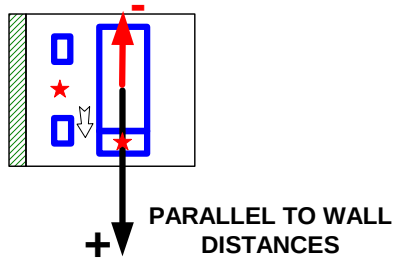
40 MPa jet release trial

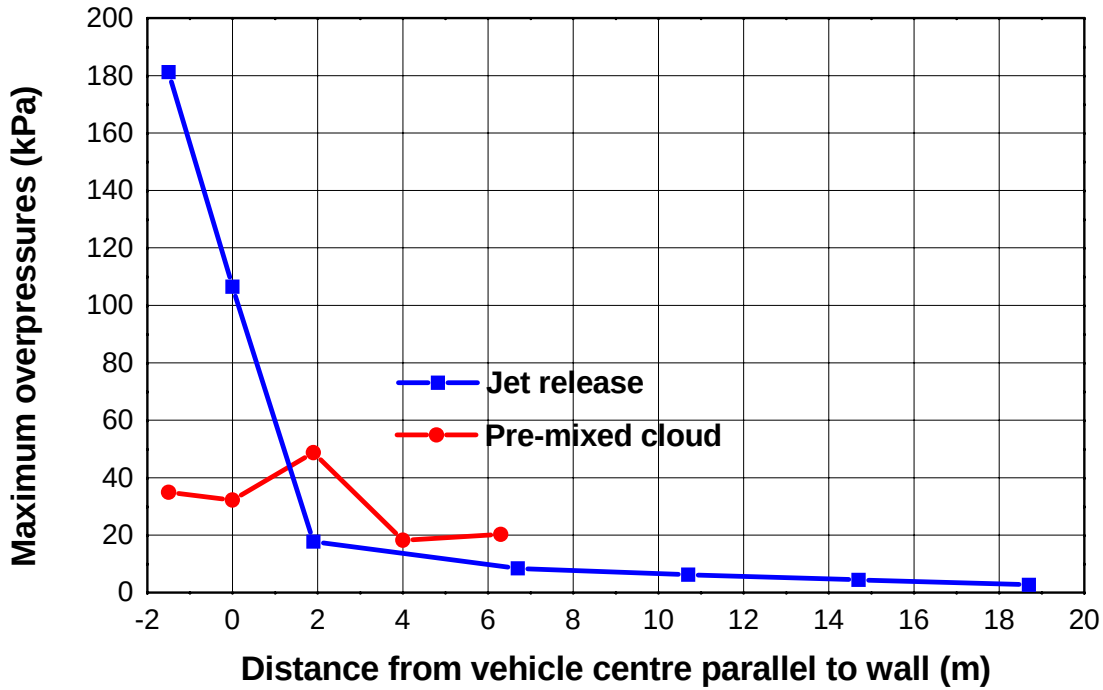
COMPARISION OF RESULTS





COMPARISION OF RESULTS





COMPARISION OF RESULTS

COMPARISION OF RESULTS

CONCLUSIONS

- Locally high overpressures (up to 180 kPa underneath the ‘vehicle’ and 87 kPa on a nearby wall) occurred within the refuelling station for jet releases;
- The highest overpressures in the far field were from ignition of premixed hydrogen-air;
- The highest local overpressures were observed in the jet release trial with a relatively short ignition time i.e. the highest pressure on ignition; and
- Both the positive and the negative impulses were much higher for premixed ignition than for jet ignition.

CONCLUSIONS

- The results obtained from both premixed clouds and jet releases are conservative because in practice the safeguarding systems should limit the quantity of hydrogen that can be released accidentally to less than that used in these experiments.
- This is currently under investigation at 700 bar.

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