Vented Confined Explosions involving Methane/Hydrogen Mixtures

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NATURALHY is an Integrated Project funded by the European Commission's Sixth Framework Programme (2002-2006) for research, technological development and demonstration (RTD)

Naturalhy Project

- EC funded project assessing the potential of adding hydrogen to the natural gas system as a means to:
  - Providing mass transportation of hydrogen to facilitate introduction of the hydrogen economy
  - Greening of gas if burned directly
- Safety Work Package looking at the change in risk to the public
  - Includes change in explosion hazard

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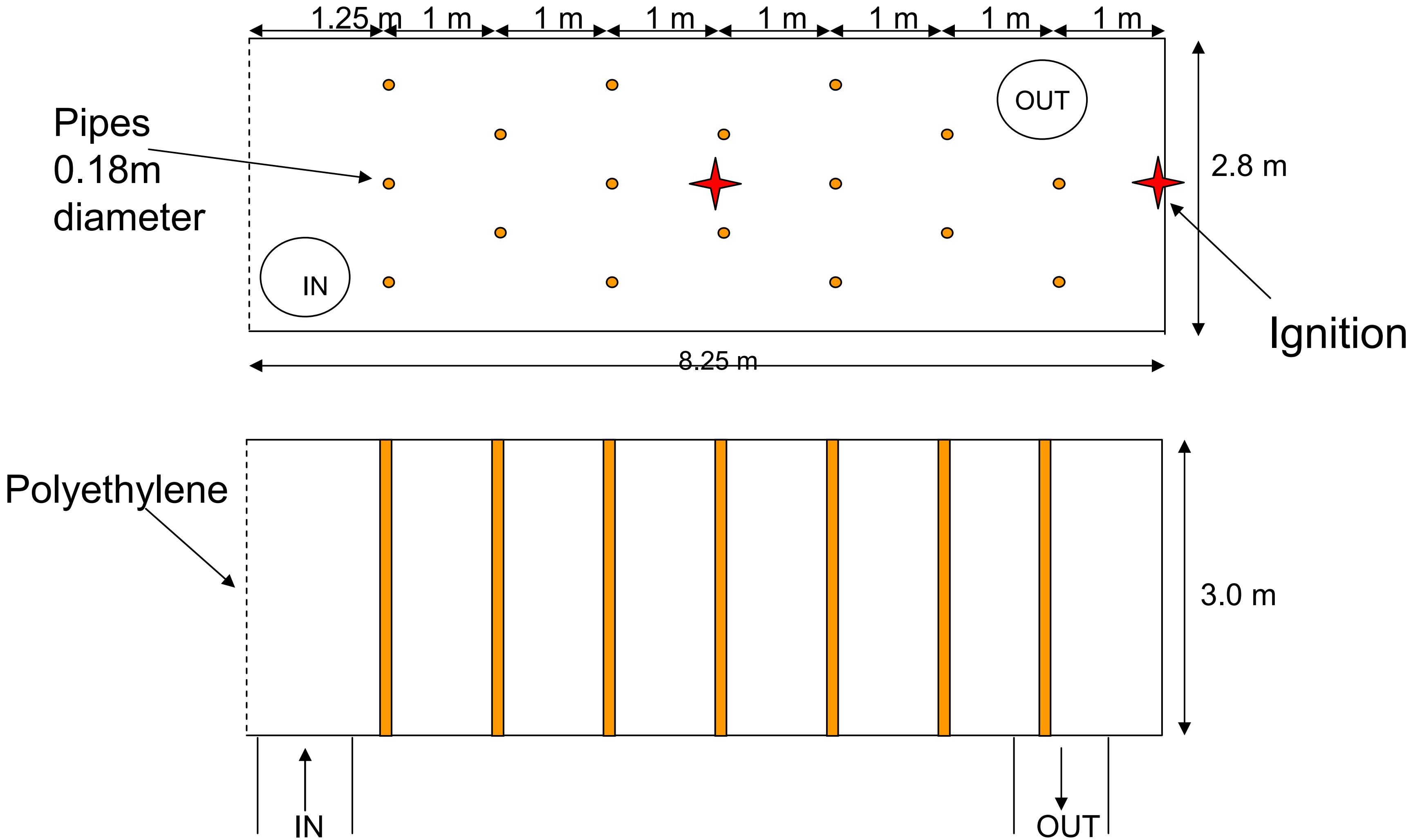
Confined Vented Explosion Experiments

- Large scale experiments with methane and 80:20, 50:50 CH_4:H_2 mixtures
- Equivalence ratio about 1.1
- 8.25m x 3m x 2.8m
- One open end wall
- Spark ignition at rear or centre
- Pipework could be included

Pipework Arrangement and Ignition



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Scientific Measurements

- Flame speed from time of arrival at locations within enclosure and video footage at vent
- Overpressure inside and outside enclosure

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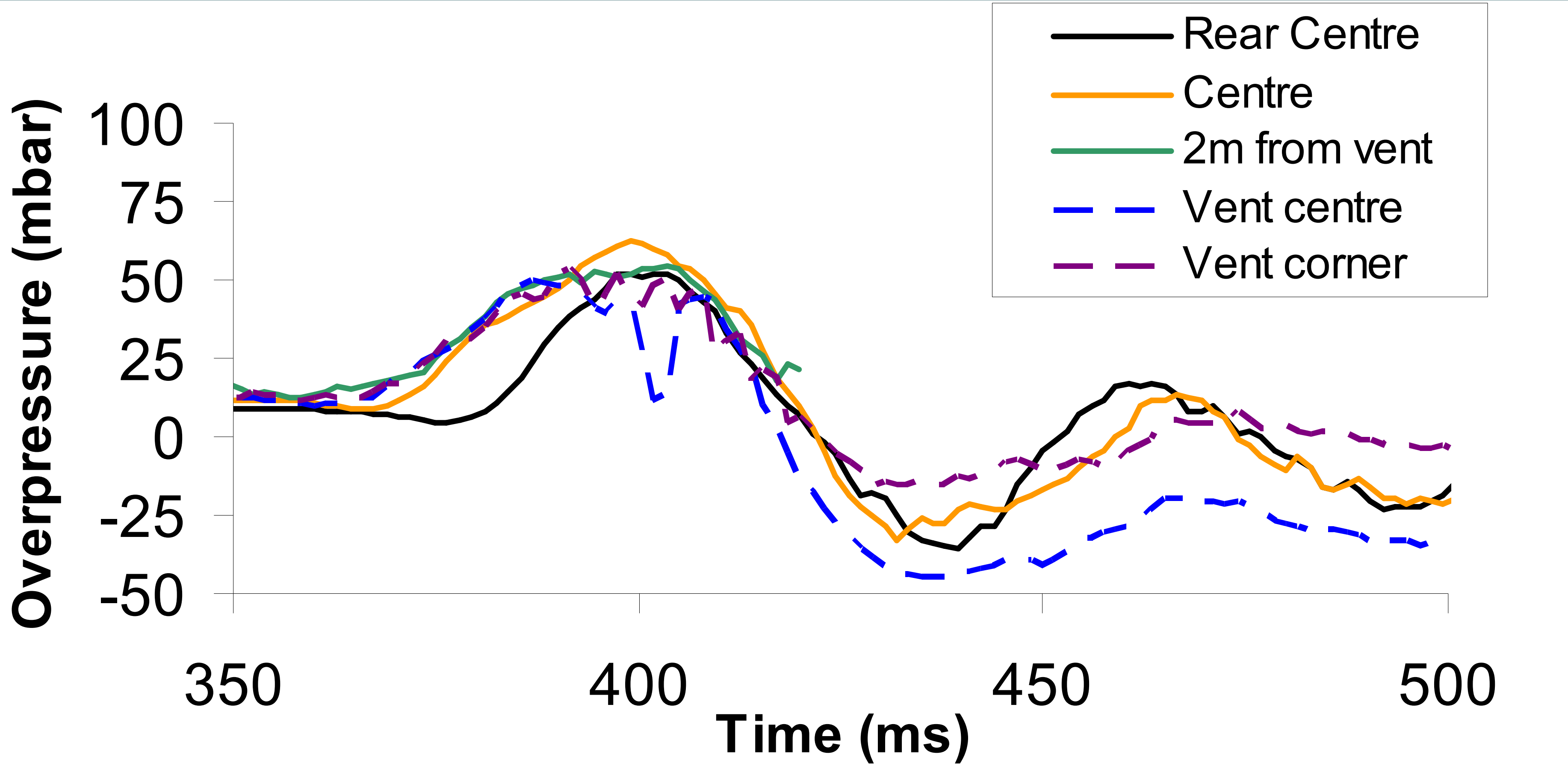
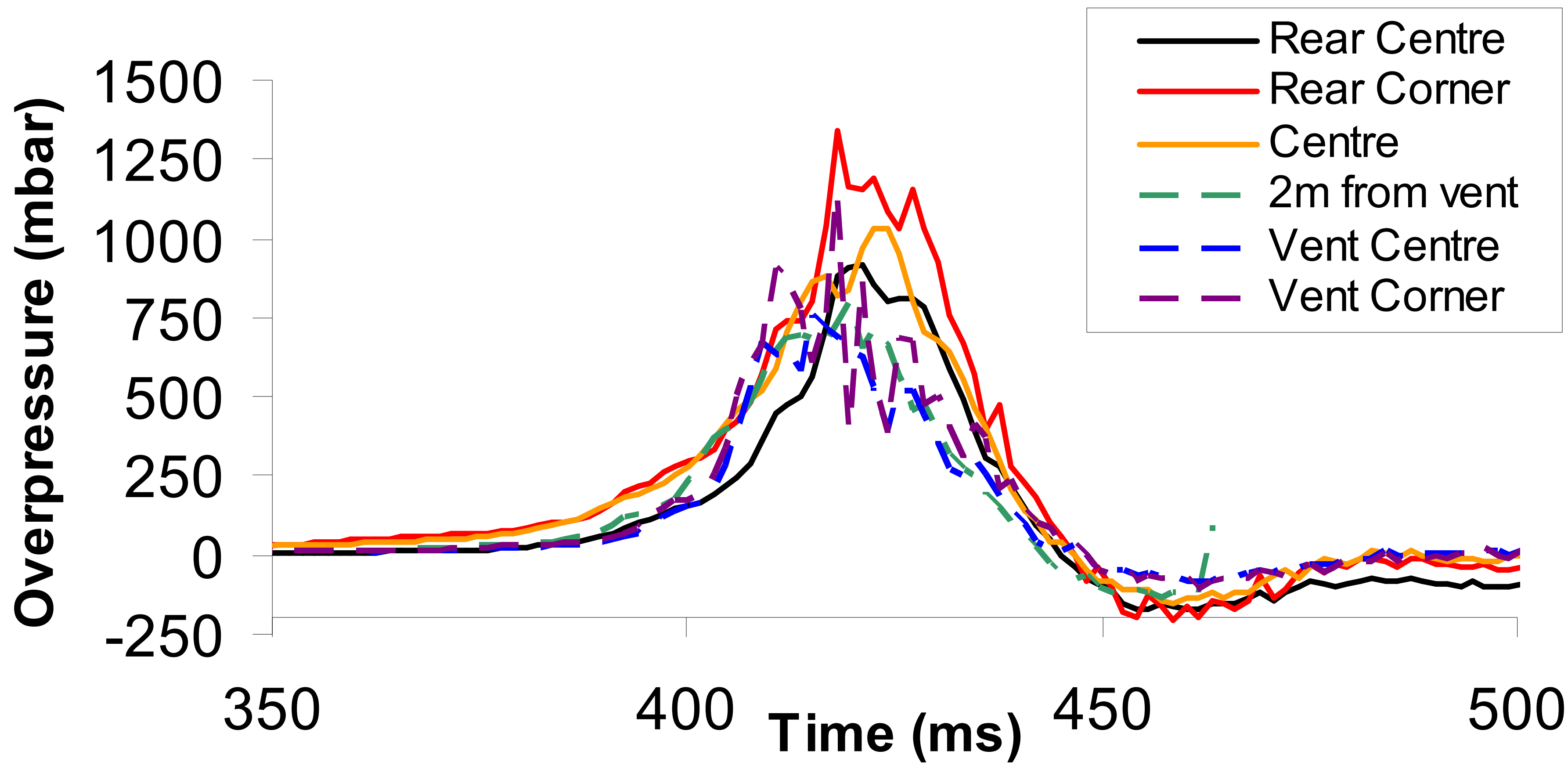
Central Ignition, No Pipes, 80:20 Mixture



Rear Ignition, 17 Pipes, 80:20 Mixture



Explosions in Buildings

Typical result for Natural Gas or Mixture with up to 20% Hydrogen

Typical result for mixture with 50% hydrogen

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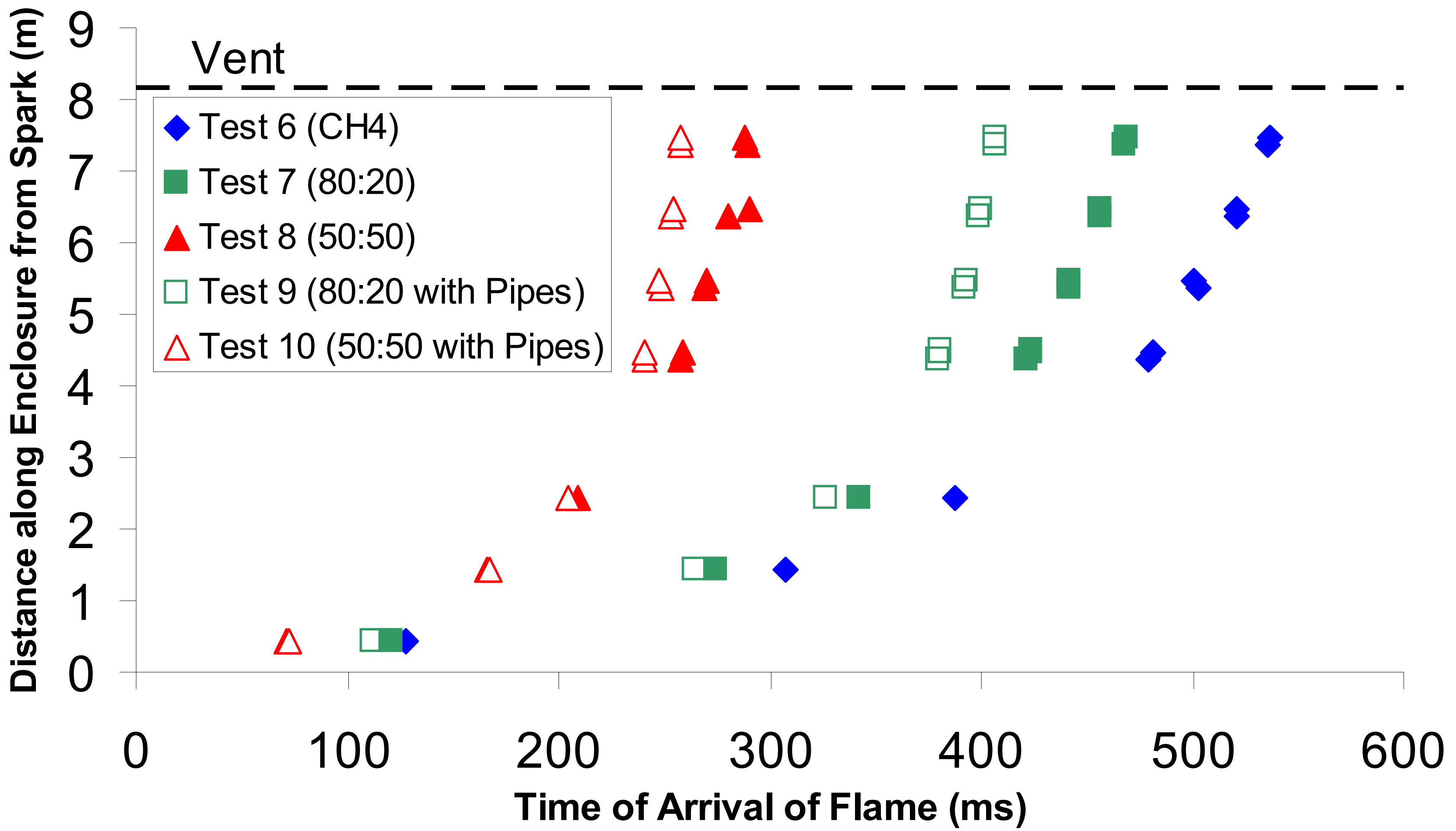
Effect of Gas Mixture and Pipework Congestion on Flame Arrival Time



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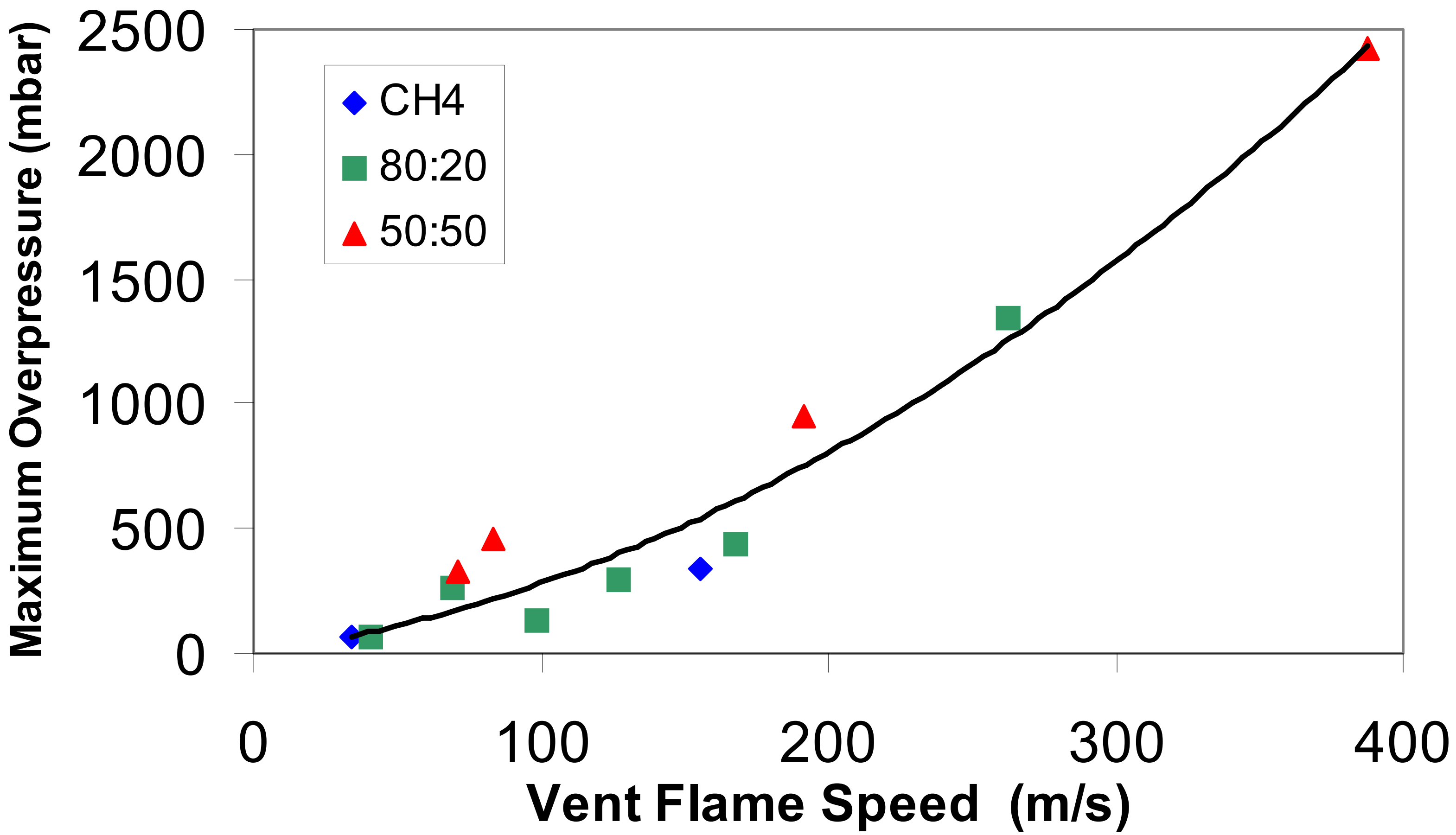
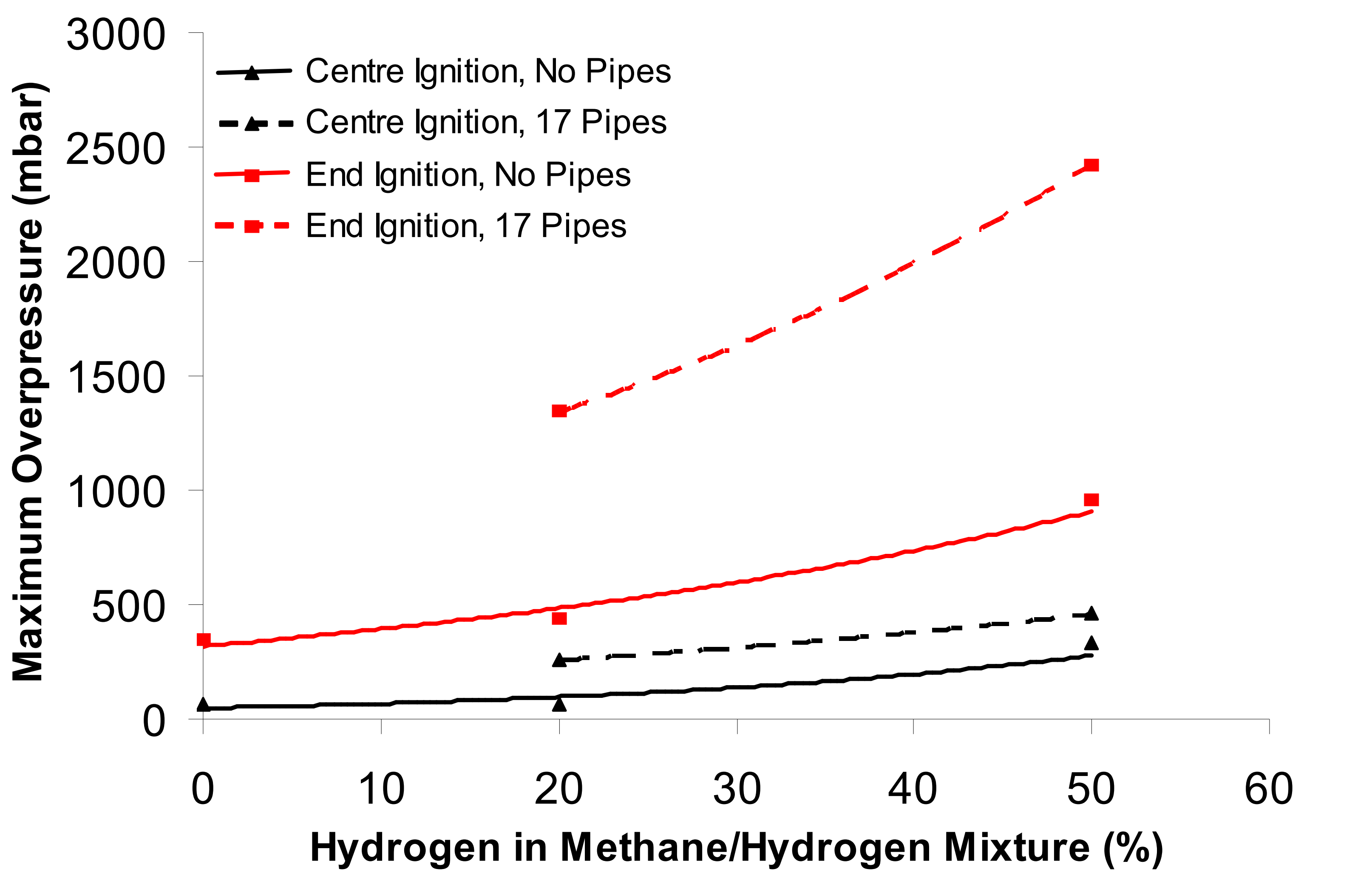
Overpressure and Flame Speed Relationship



Maximum Overpressure for Different Fuels



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Modelling Using SCOPE

- Shell model SCOPE for vented confined explosions with rear wall ignition
- Flame initially hemi-spherical until reaches walls
- Unburnt mass monitored allowing for combustion and venting
- Self acceleration included
- Flame speed is dominant parameter for overpressure

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Modification of SCOPE

- SCOPE developed for various hydrocarbons but not able to predict for methane/hydrogen mixtures
- Turbulent burning velocity based on laminar burning velocity and Markstein number
- Data obtained within Naturalhy project on laminar burning velocity and Ma for CH_4:H_2 mixtures at 360K
- Temperature corrected using expressions of the form

$$\frac{u_1}{u_0} = \left(\frac{T_1}{T_0}\right)^m$$

- Polynomial fits for m from kinetic modelling as function of ER

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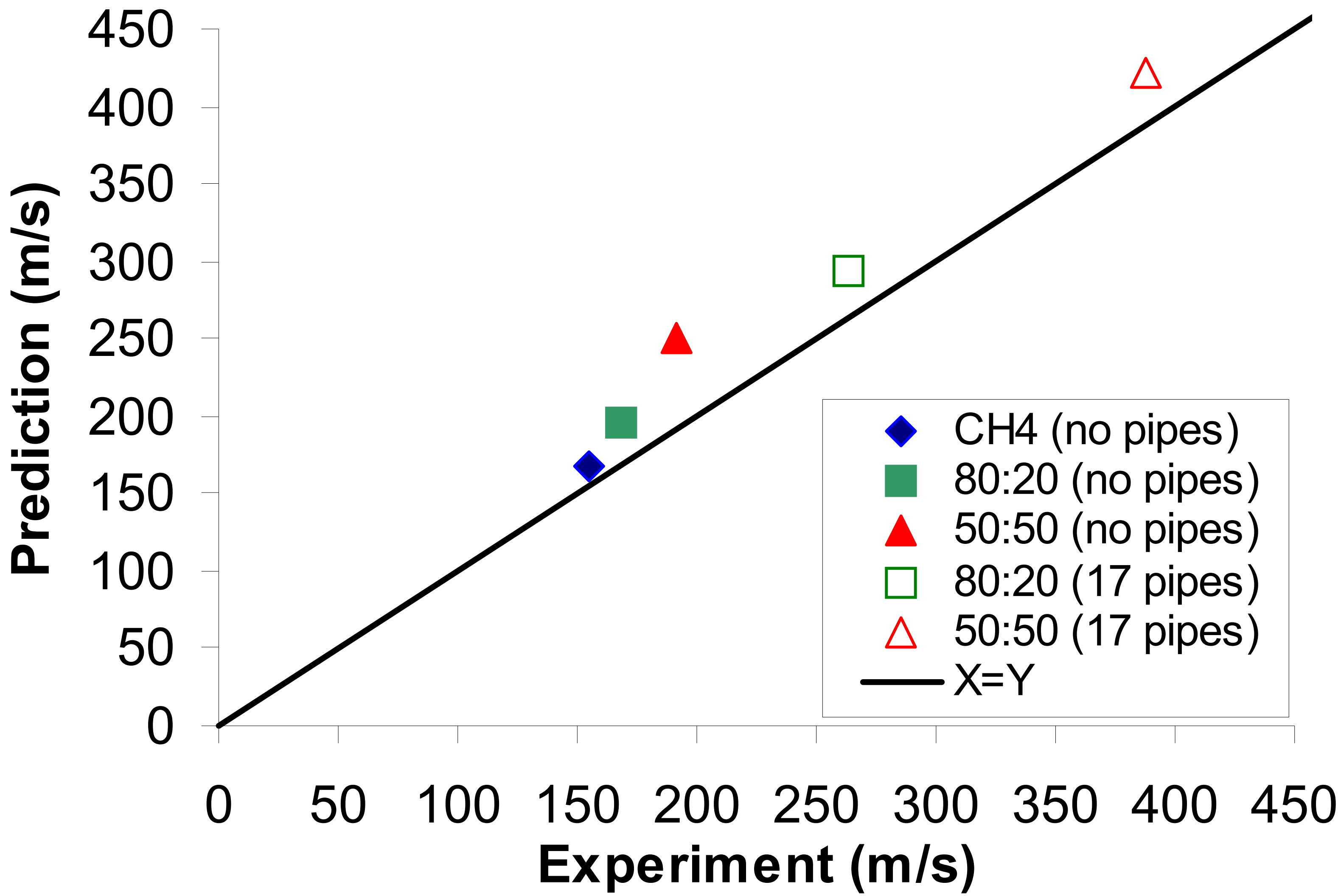
Predictions – Flame Speed at Vent



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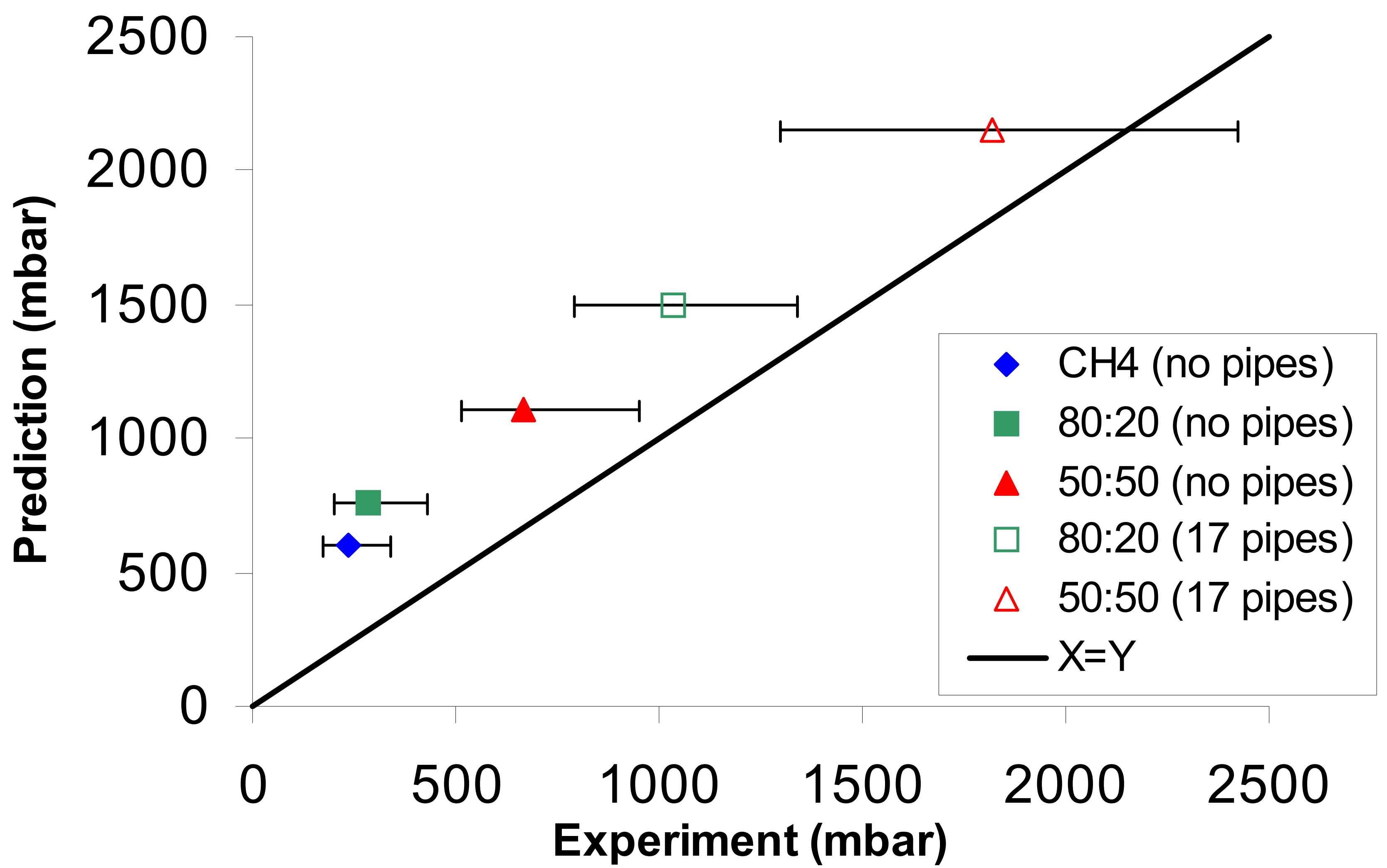
Predictions of Overpressure



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Conclusions

- Large scale data on explosions of methane/hydrogen mixtures obtained
- Modest increase in severity for addition of 20% (by vol) H_2
- Significant increase for 50%(by vol) H_2
- Ignition location and congestion also increased pressures
- A modified version of SCOPE can predict the consequences of these explosions

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