



# **DDT in a vapour cloud explosion in unconfined and congested space: large scale test**

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## REASONING FOR UNDERSTANDING

### A very brief summary of Buncefield accident

1. Accidental spill of about 300 tons of gasoline at still weather conditions at the Hertfordshire Oil Storage Terminal (UK)
2. Formation of large flammable cloud followed by a delayed ignition, explosion occurred at 06:01 GMT on Sunday, 11 December 2005
3. Very high overpressure damages both near- and far-field
4. Glass window damage up to about 5 miles (8 km)
5. The British Geological Survey monitored the event: 2.4 on the Richter scale
6. No fatalities, 43 reported injuries
7. 1.5 billion GBP damage (ref New Scientist 31 March 2012)

# REASONING FOR UNDERSTANDING

## Car damage after the Buncefield accident



AIChE/CSChE LNG  
Symposium,  
August 2009,  
after James Venart



# OUTLINE

## Presentation outline

1. Can detonations occur in accidents or these are too difficult to initiate?
2. This is a high level presentation of **some recent flame acceleration, large scale experimental tests:**
  - a) Harries R J, Wickens M J, (1989), The institute of gas engineers
  - b) Buncefiled JIP (2011) Flame acceleration in pine trees (propane/air)
  - c) Buncefiled JIP (2012) DDT in deciduous trees (propane/air)
  - d) Shell flame acceleration tests (2012) in unconfined but congested space (ethane/air)
3. Jaipur accident (Hazards XXIII (2012), by Mike Johnson)
4. Retrospection: e.g. Ufa accident

## **HARRIES, WICKENS EXPERIMENTAL WORK**

**Harries R J, Wickens M J, (1989), "Understanding vapour cloud explosions – an experimental study", The institute of gas engineers**

- 1. Ignition by weak ignition source or vented explosion**
- 2. Repeated obstacles in 45 m long rig**
- 3. Deflagration to detonation transition did occur for cyclohexane/air and propane/air mixture**



# PART OF THE JIP BUNCEFIELD RESULTS

## Buncefiled JIP (2011) Flame acceleration in pine trees

(propane/air), (ref New Scientist 31 March 2012, and

<http://www.newscientist.com/blogs/nstv/2012/04/explosion-simulates-mysterious-buncefield-blast.html> )

1. Ignition by weak ignition source of propane/air mixture
2. Flame accelerated initially but after attaining certain velocity its speed leveled off, no DDT



Video 1

## PART OF THE JIP BUNCEFIELD

**Buncefielded JIP (2011) DDT in deciduous trees (propane/air),**

(ref New Scientist 31 March 2012, and

<http://www.newscientist.com/blogs/nstv/2012/04/explosion-simulates-mysterious-buncefield-blast.html> )

1. Ignition by weak ignition source of propane/air mixture
2. Flame accelerated and deflagration to detonation transition occurred



Video 2



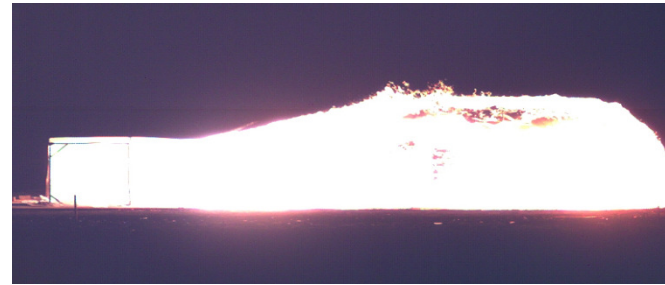
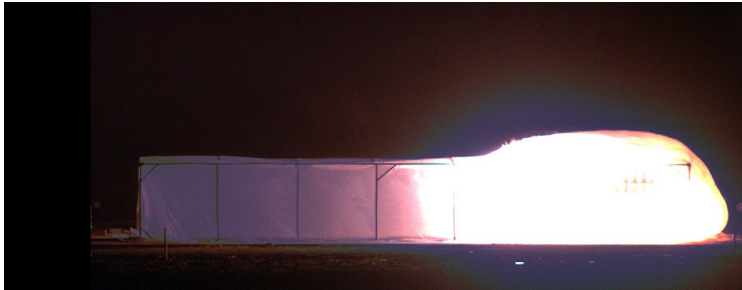
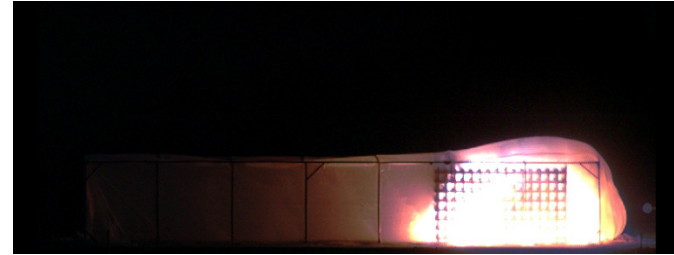
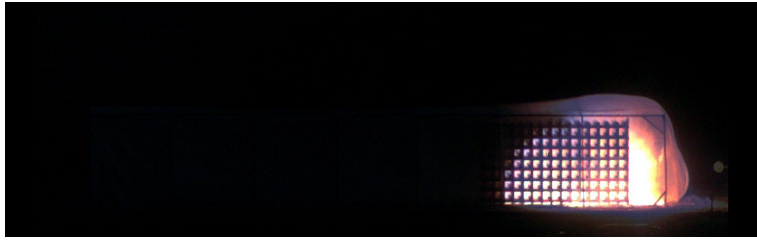
## SHELL FLAME ACCELERATION TESTS (1/3)

Shell flame acceleration tests (2012) in unconfined but congested space (ethane/air)

1. Ignition by weak ignition source
2. Polyethylene tent of 20 x 6 x 3 m filled by flammable ethane/air mixture
3. Congested rig of 5.2 x 5.2 x 2.6 m, inside the tent with edge ignition
4. Instrumentation: Pressure sensors, Ionization probes, fast framing cameras

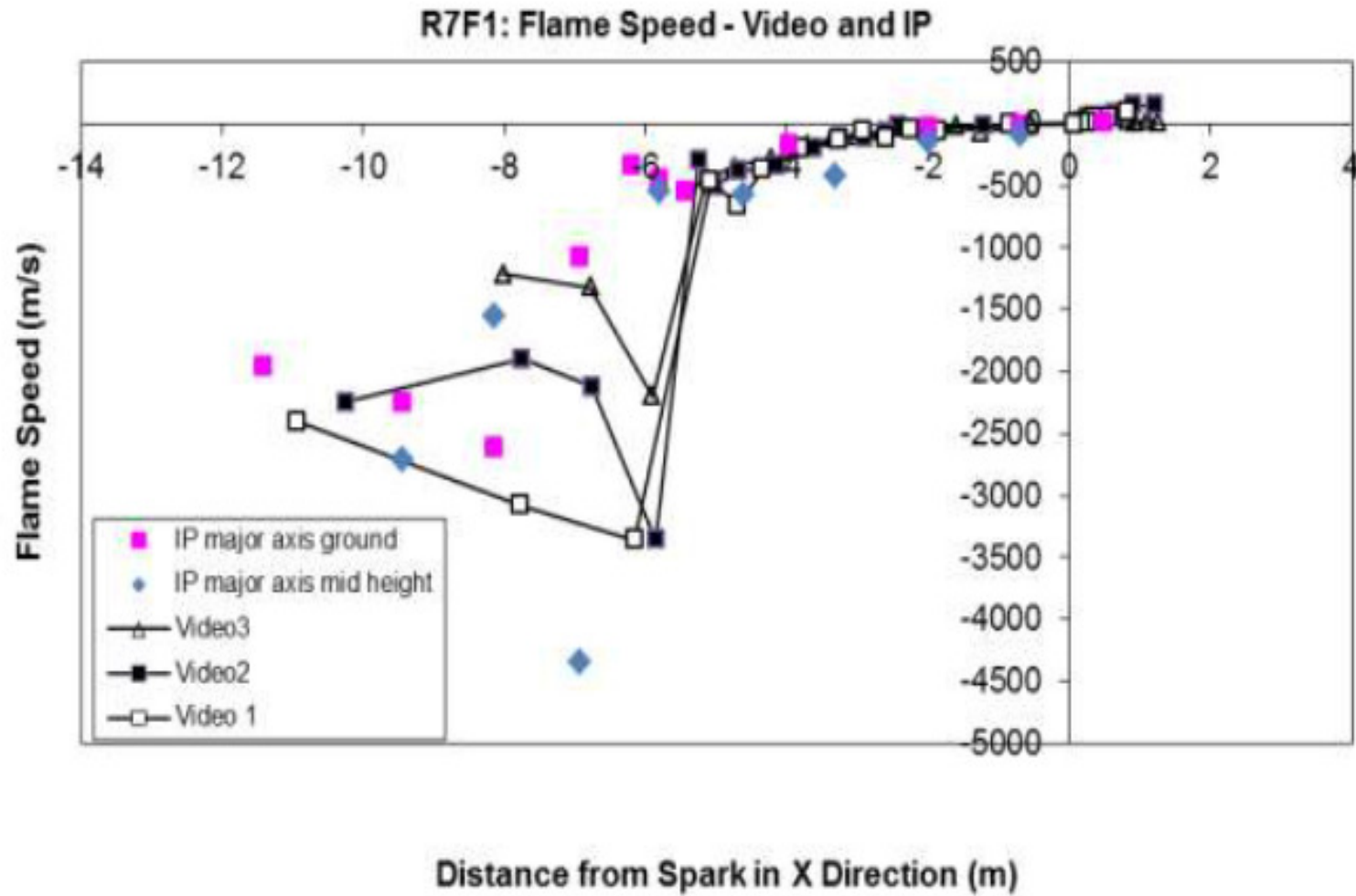


# SHELL FLAME ACCELERATION TESTS (2/3)



Video 3

# SHELL FLAME ACCELERATION TESTS (3/3)



## **JAIPUR ACCIDENT**

**Jaipur accident (Mike Johnson, "VAPOUR CLOUD EXPLOSION AT THE IOC TERMINAL IN JAIPUR" Hazards XXIII, UK, p 556 (2012))**

- 1. Accidental spill of about 1000 tons of gasoline in calm, low wind speed, conditions at the on the Indian Oil Corporation's (IOC) Petroleum Oil Lubricants Terminal at Jaipur (India)**
- 2. Spill occurred at approximately 6:10pm on 29th October 2009 leading to formation of large flammable cloud followed by a delayed ignition 75 minutes later**
- 3. Very high similarities to Buncefield accident with respect to damage**
- 4. It was concluded that the damaging overpressure was generated by detonation**

## RETROSPECTION (1/2)

**For instance: Ufa accident (3 June 1989)** ref. e.g. G. M.

MAKHVILADZE and S. E. YAKUSH, Proceedings of Combustion Institute, Volume 29, 2002/pp. 195–210

- 1. Release of hydrocarbons from a large transmission pipeline near Ufa**
- 2. Release over several hours leading to formation of a very large flammable cloud in a forest**
- 3. Delayed ignition by two trains traveling in opposing direction (additional turbulence mechanism) leading to the accident**
- 4. Many fatalities and injured**
- 5. Windows were broken 15 km away from the accident site**



## RETROSPECTION (2/2)



What might be concluded in the light of the current experimental evidence with respect to the overpressure generation mechanism ?



**Thank you for attention**  
**Questions are welcome**

