Background to the development of hydrocarbon explosion and fire guidance

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FABIG
Fire and Blast Information Group

EUROPEAN CONFERENCE ON PLANT & PROCESS SAFETY

11 & 12 DECEMBER 2019
COLOGNE, GERMANY

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Overview

- Key milestones in explosion and fire research
  - Piper Alpha (1988)
  - Buncefield (2005)
- Research programmes and examples of tests performed
- Main outcomes and findings leading to industry guidance
- The Fire and Blast Information Group (FABIG)
  - Origins
  - Activities

Piper Alpha Disaster, 6 July 1988

- Worst offshore accident 167 fatalities
- Escalation chain started with loss of containment
- Escalation chain could have been broken at several points, one being the explosion
- Understanding the load generated by explosions allows design to prevent escalation

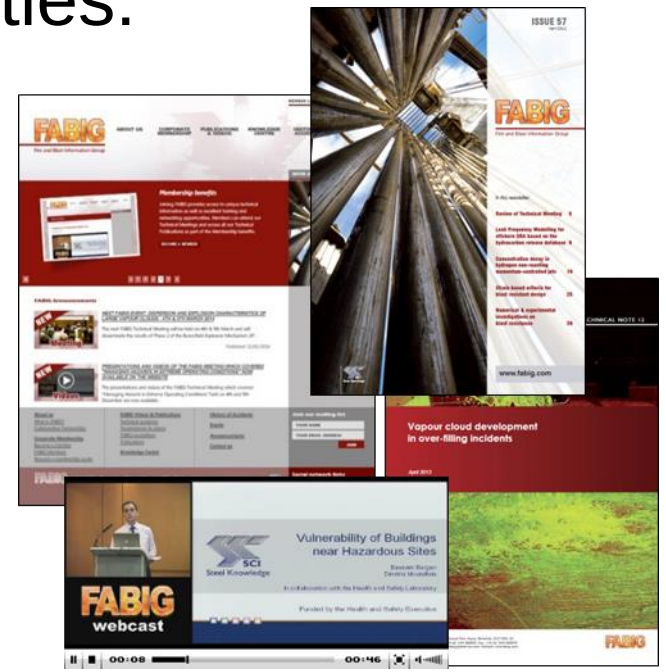
BFETS(1) - Phase 1 (1989-1991)

- State of knowledge
  - Explosion loading
  - Explosion response
  - Fire loading
  - Fire response
- Delivered *Interim Guidance*
- Project partners
  - SCI
  - DNVGL (formerly BG)
  - Shell

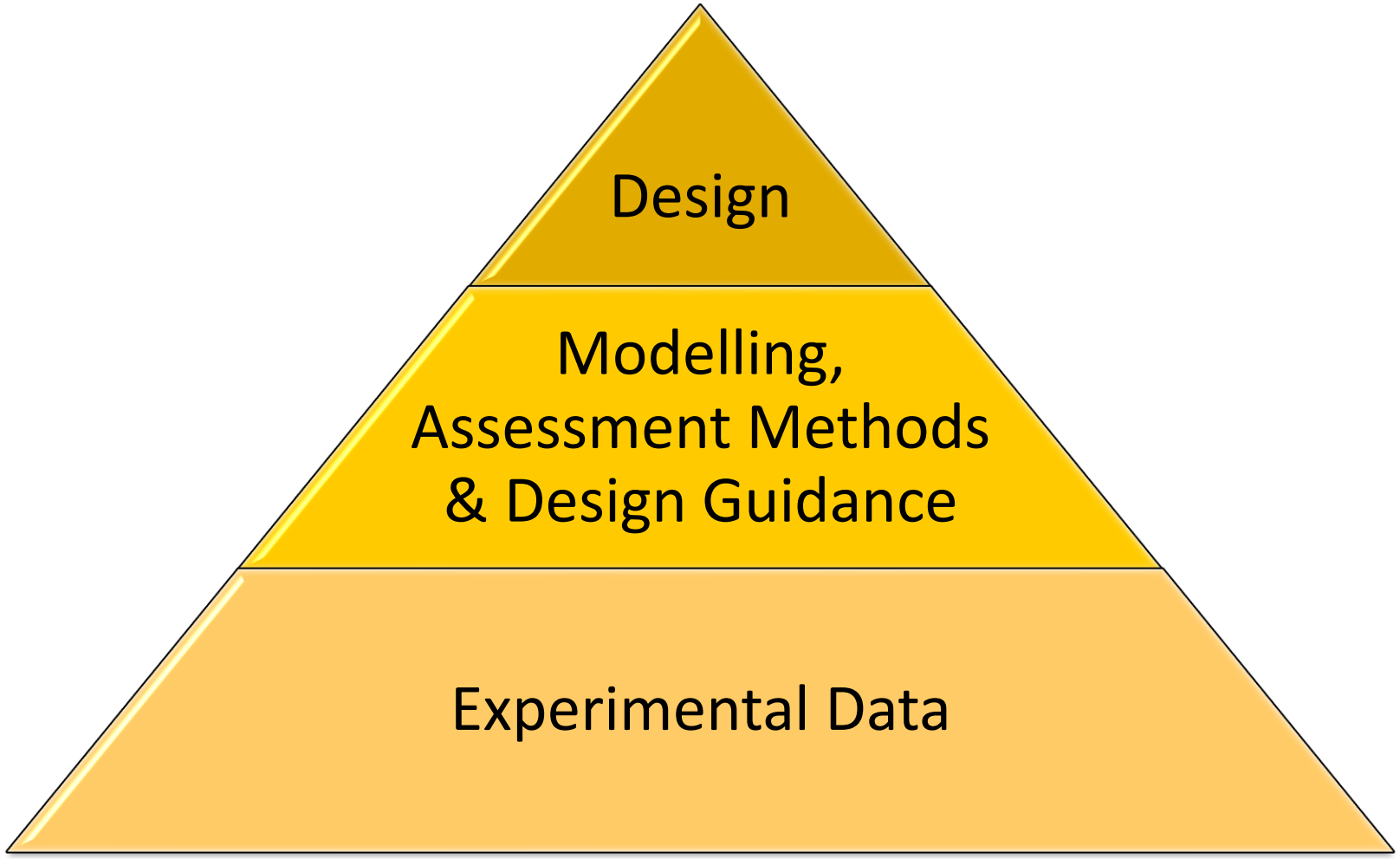
(1) Blast and Fire Engineering Project for Topside Structures

Fire And Blast Information Group - FABIG

- Established in 1992 in the wake of the Piper Alpha disaster and following BFETS Phase 1 to provide the oil & gas industry with a forum for sharing knowledge and best practice in fire & explosion engineering by undertaking the following activities:
  - Developing guidance;
  - Organising technical meetings;
  - Publishing a technical newsletters.
- Launched with circa 40 corporate members



BFETS Phase 1: Lack of full scale validation of models

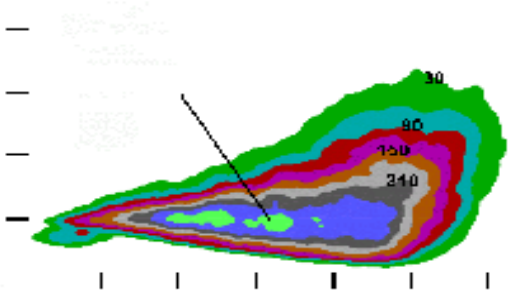


BFETS - Phase 2 (1993-1997)

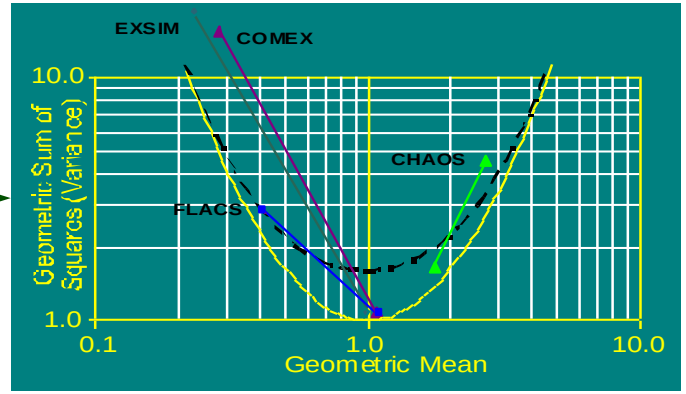
SINTEF

DNVGL (Spadeadam)

DNVGL (Spadeadam)



BEFTS
Phase 2



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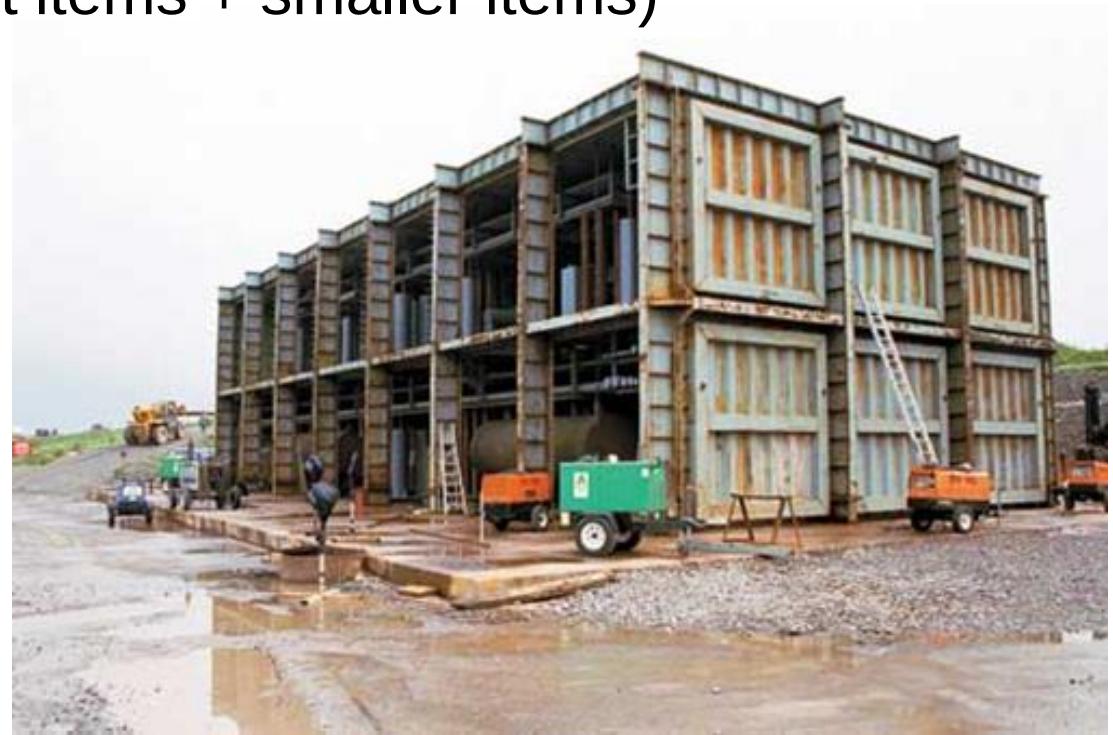
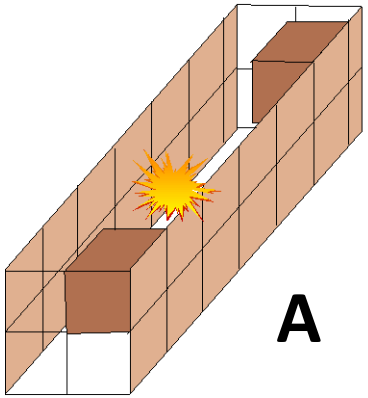
BFETS - Phase 2 (1993-1997) – Explosion Tests

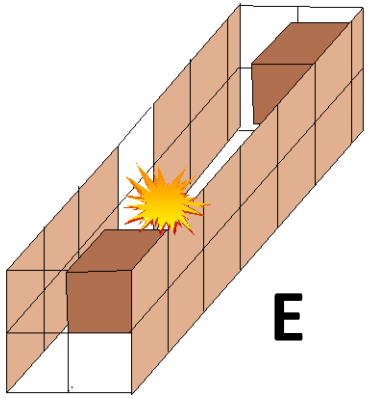
- Purpose built test rig 28m x 12m x 8m high
- 27 full-scale explosion tests
- Factors studied:
  - Congestion (large equipment items + smaller items)
  - Confinement
  - Size of module
  - Ignition location
  - Gas concentration
  - Effect of water deluge

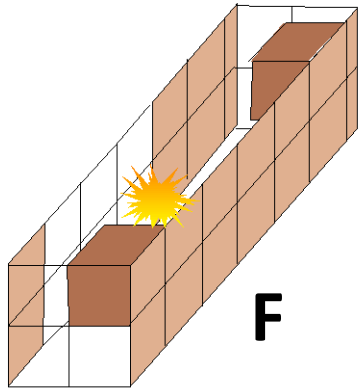


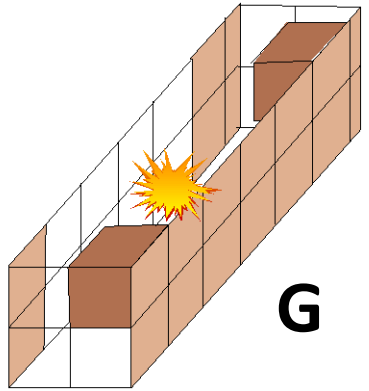
Explosion test rig

- Confinement

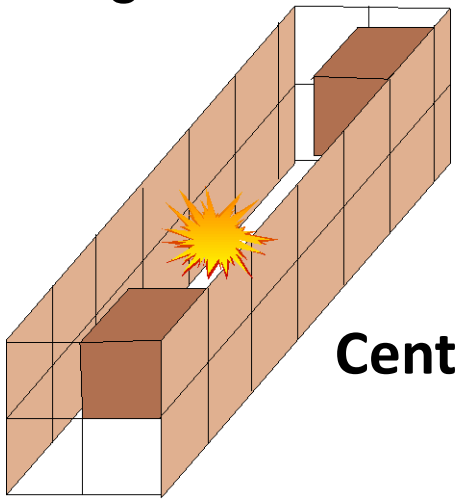


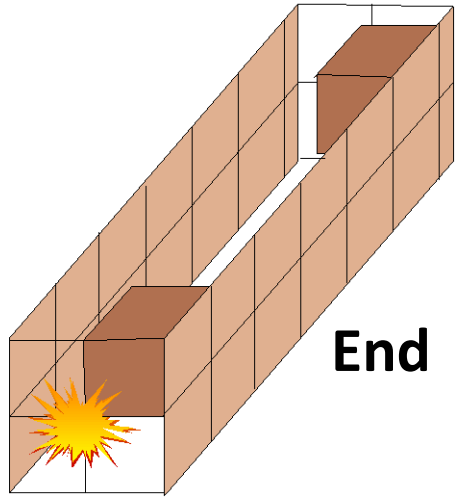






- Ignition location

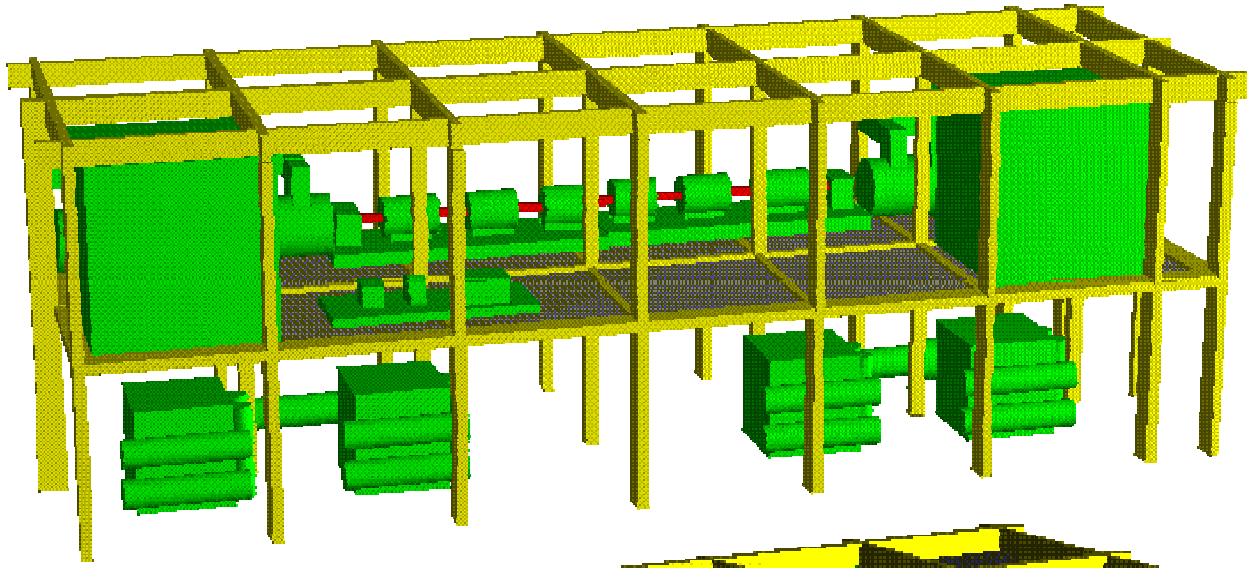




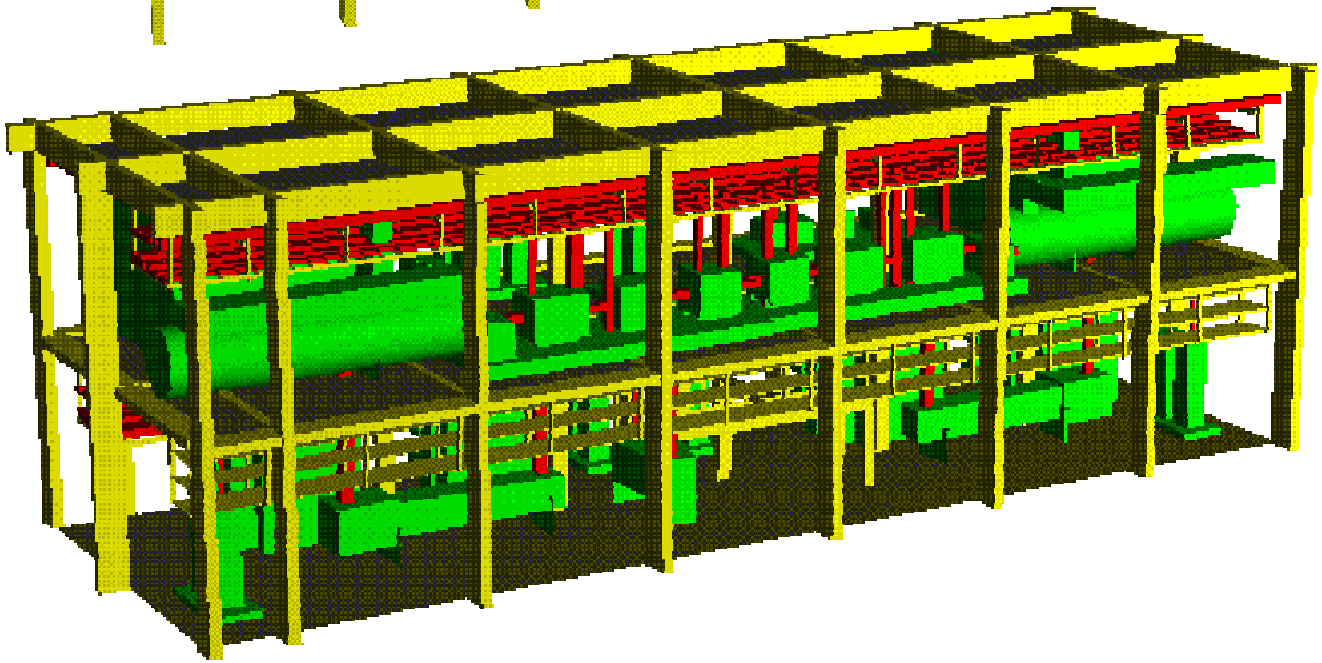
Explosion test rig

- Congestion

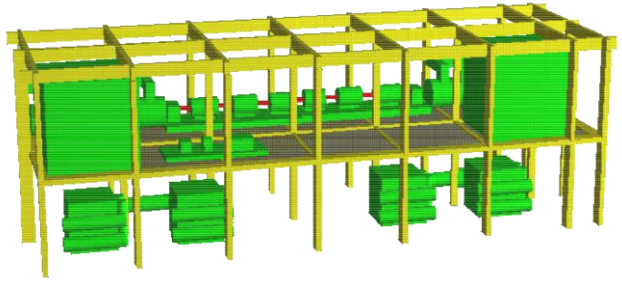
Low

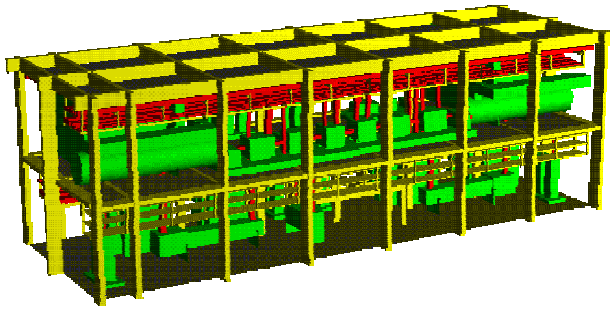


High



Ignition location and congestion





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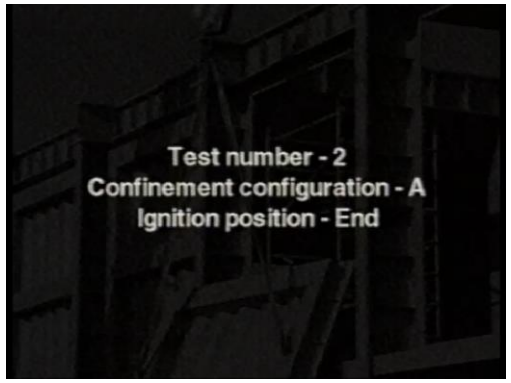
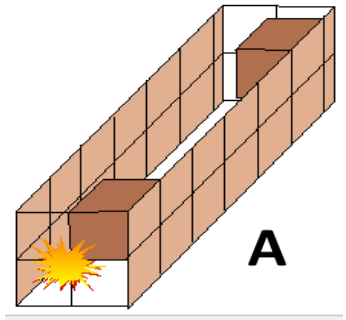
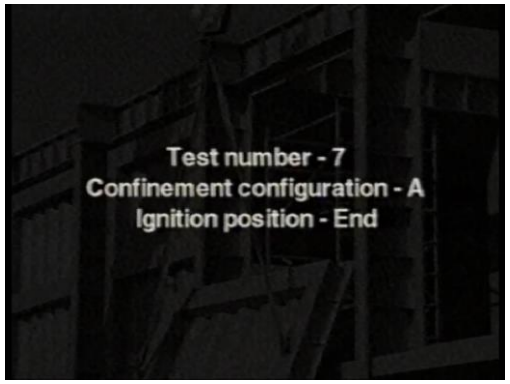
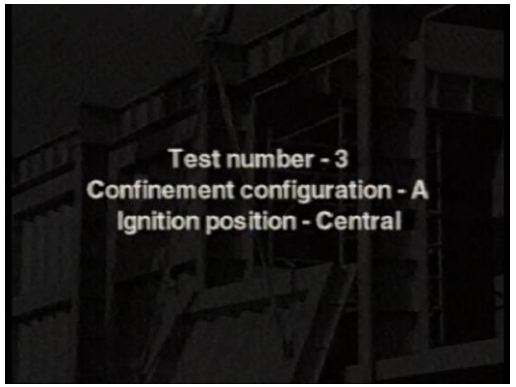


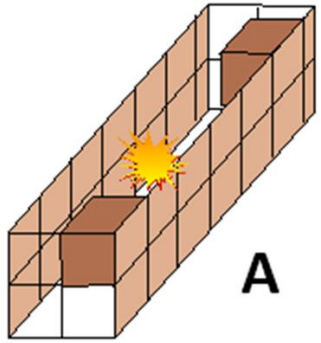




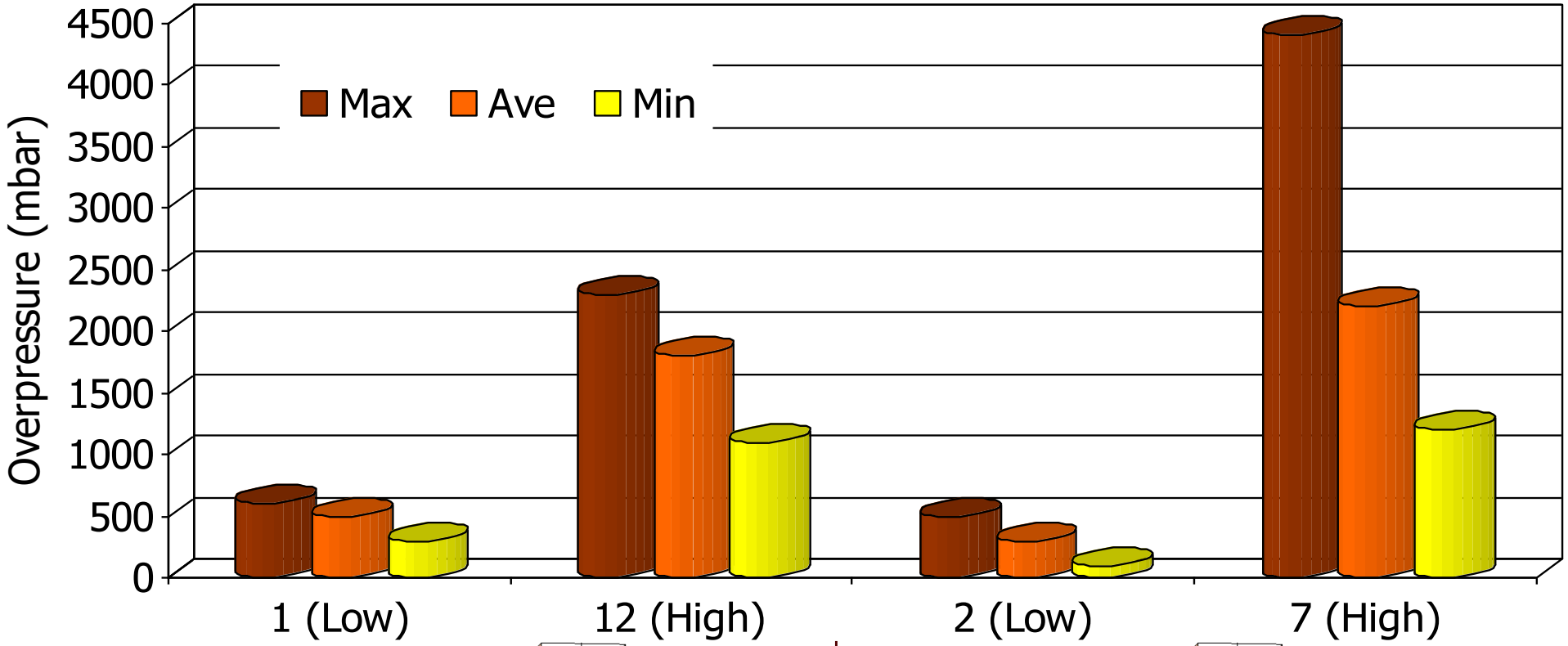
(3)

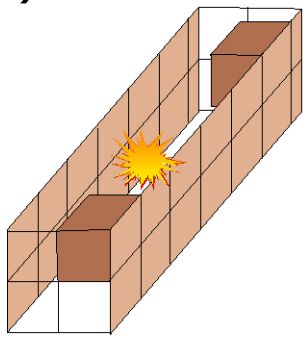
(1)

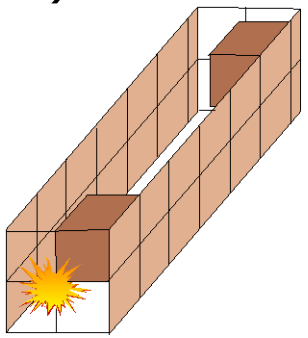




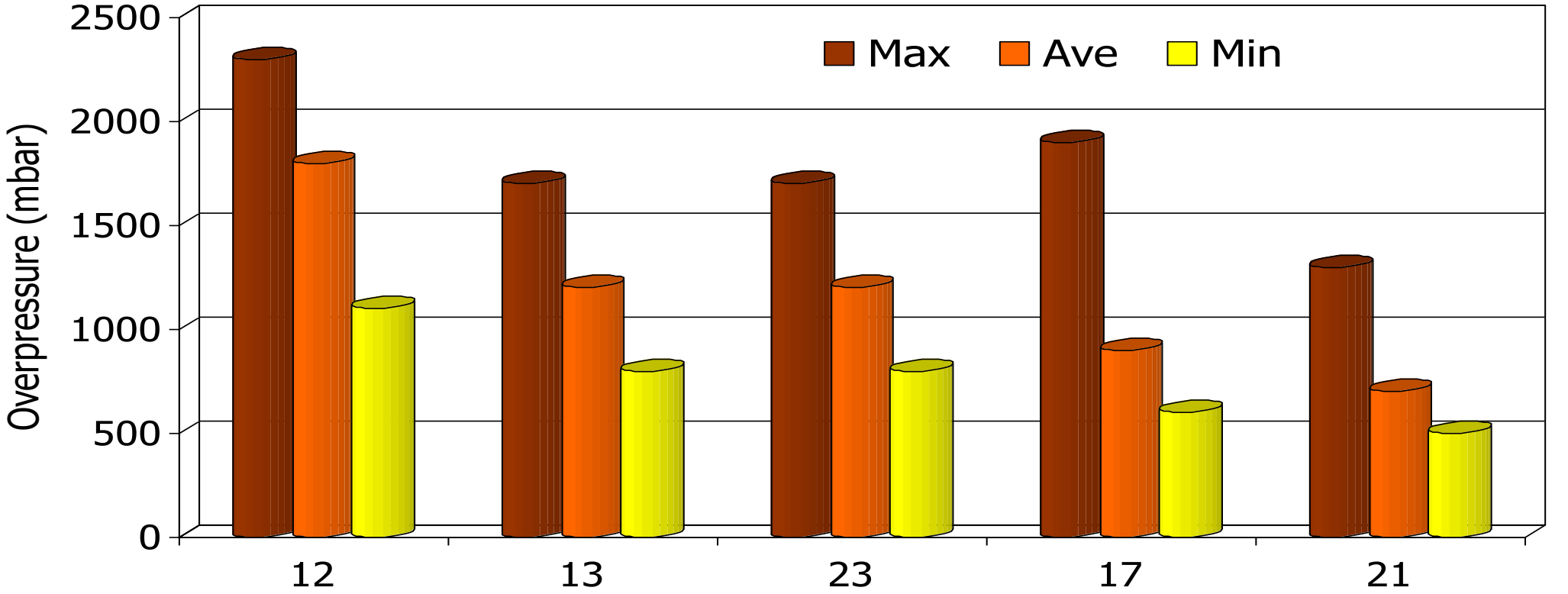
Congestion and Ignition Location

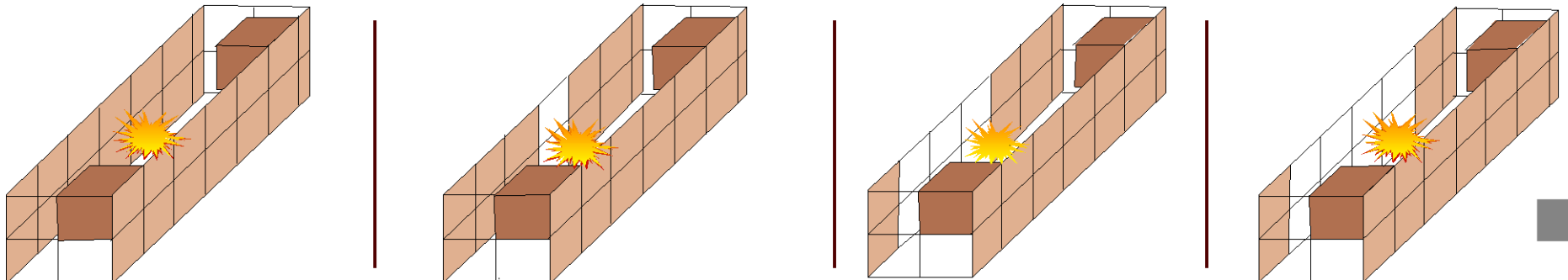




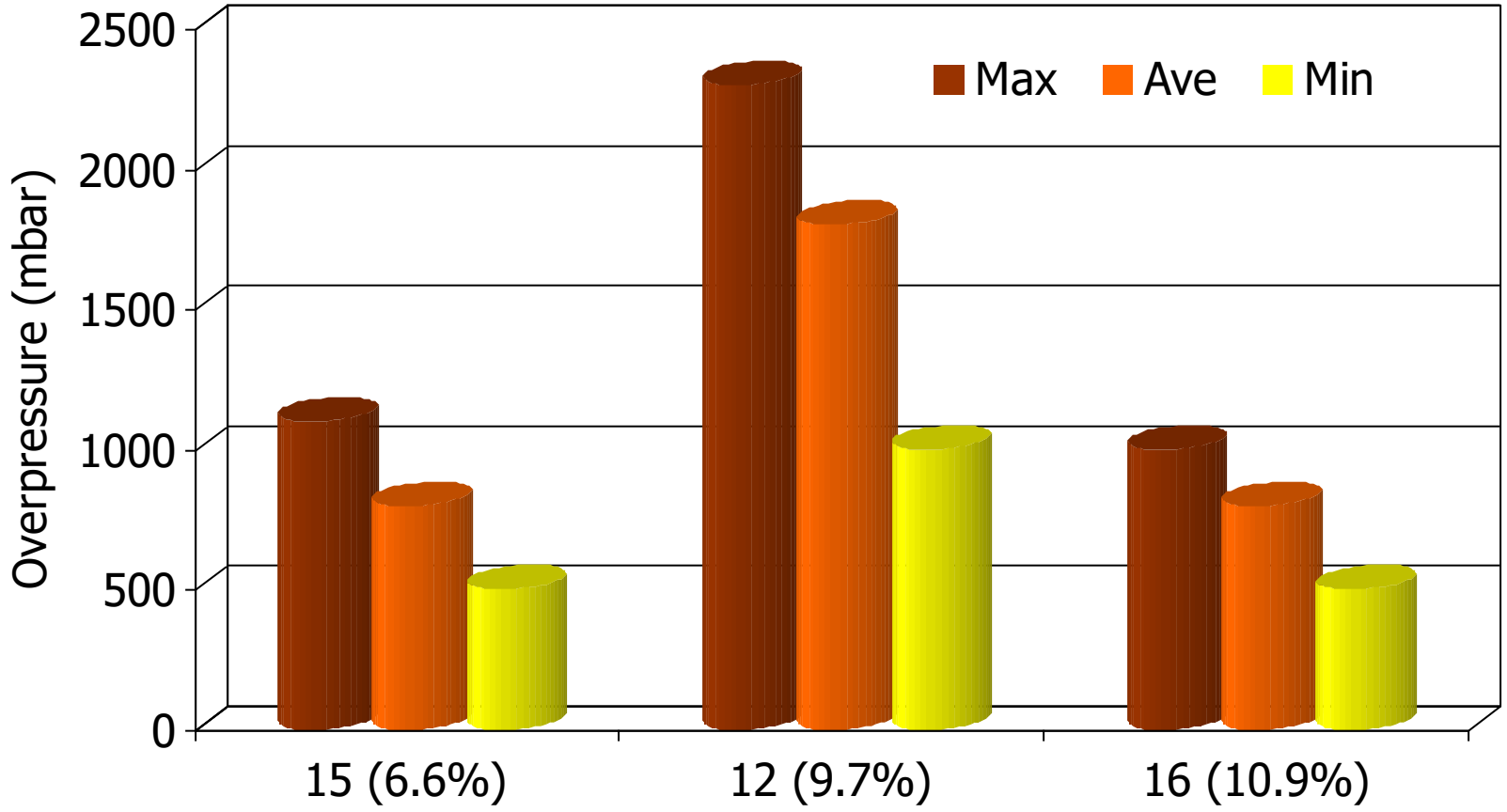


Confinement

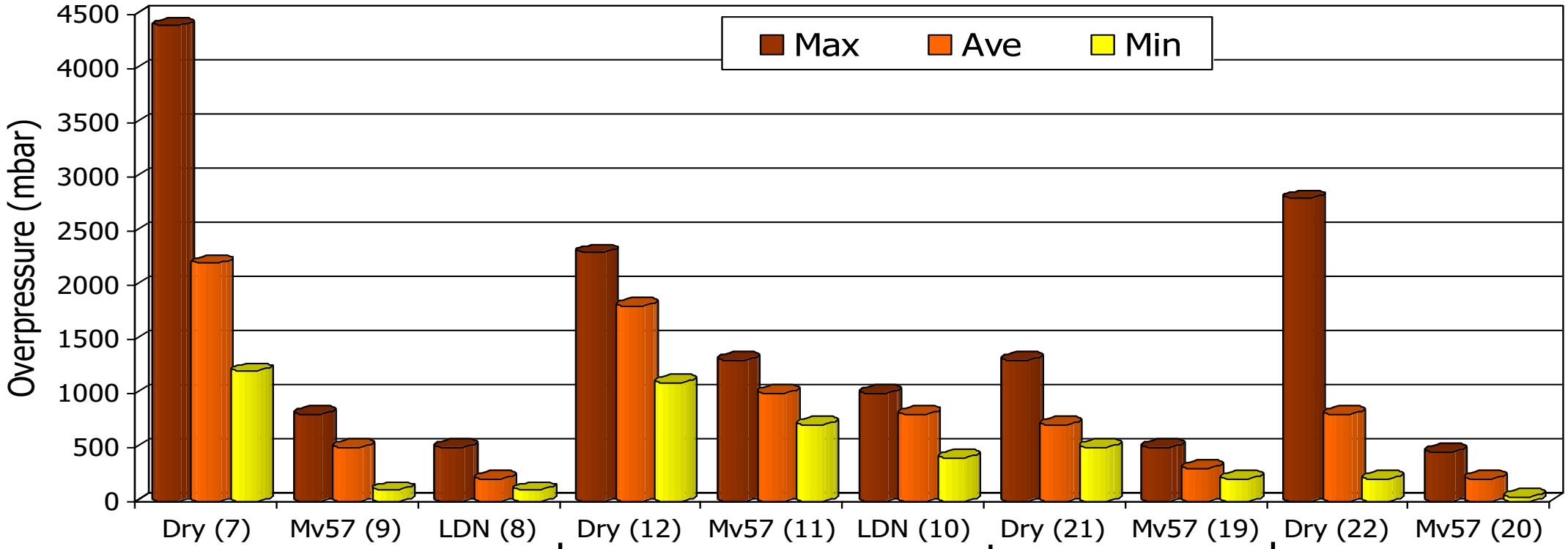


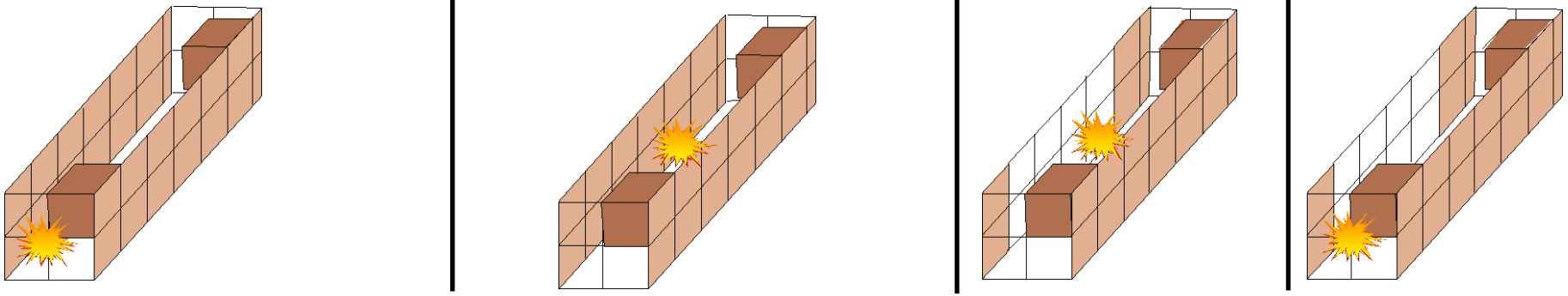


Effect of Gas Concentration



Effect of Water Deluge





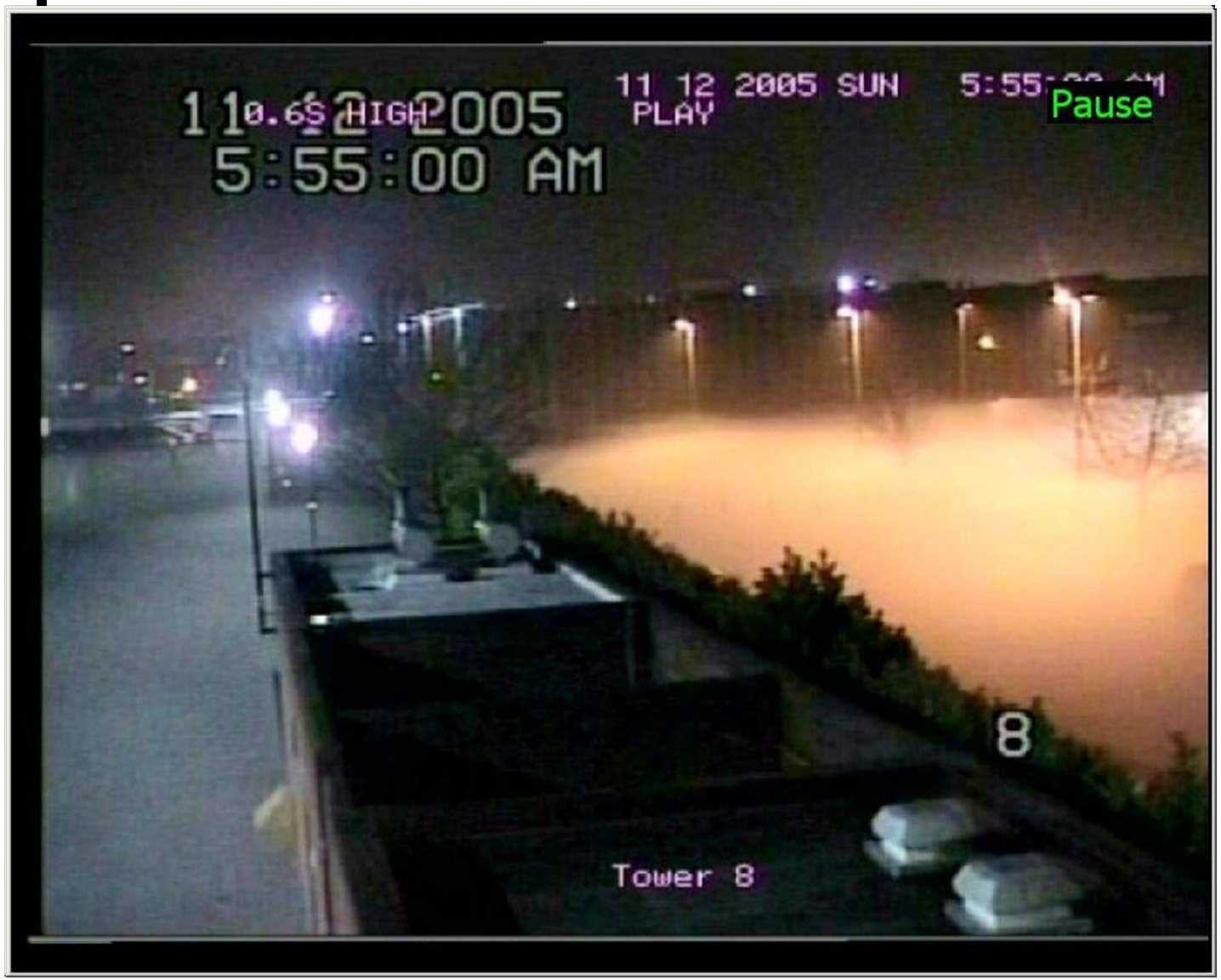
Outcomes from explosion tests

- Significant amount of data for model validation
- High overpressures (several bars) are possible
- Water deluge activated prior to ignition reduces peak overpressure
- Follow-up tests
  - Gas dispersion studies (different release and confinement conditions)
  - ‘Realistic explosions’ – partial fill stoichiometric clouds & high pressure release transient clouds
- For realistic explosion scenarios
  - Pressures generally significantly less than the worst case
  - Worst case pressures were however achieved in some tests
- Unlikely to be able to design for worst case
- Need a risk-based approach, based on ‘realistic’ conditions

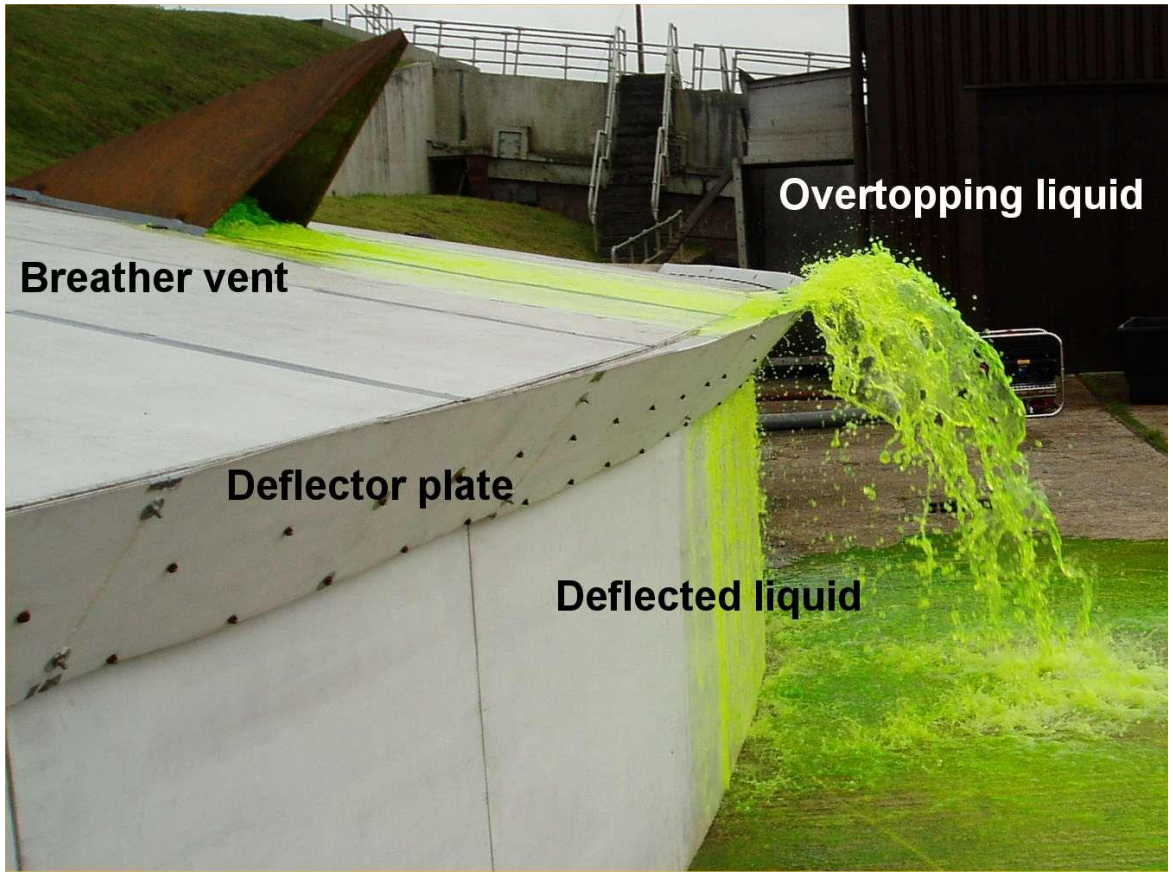
Buncefield – Sunday 11 Dec 2005

Buncefield – Physical Damage

Buncefield – Vapour Cloud

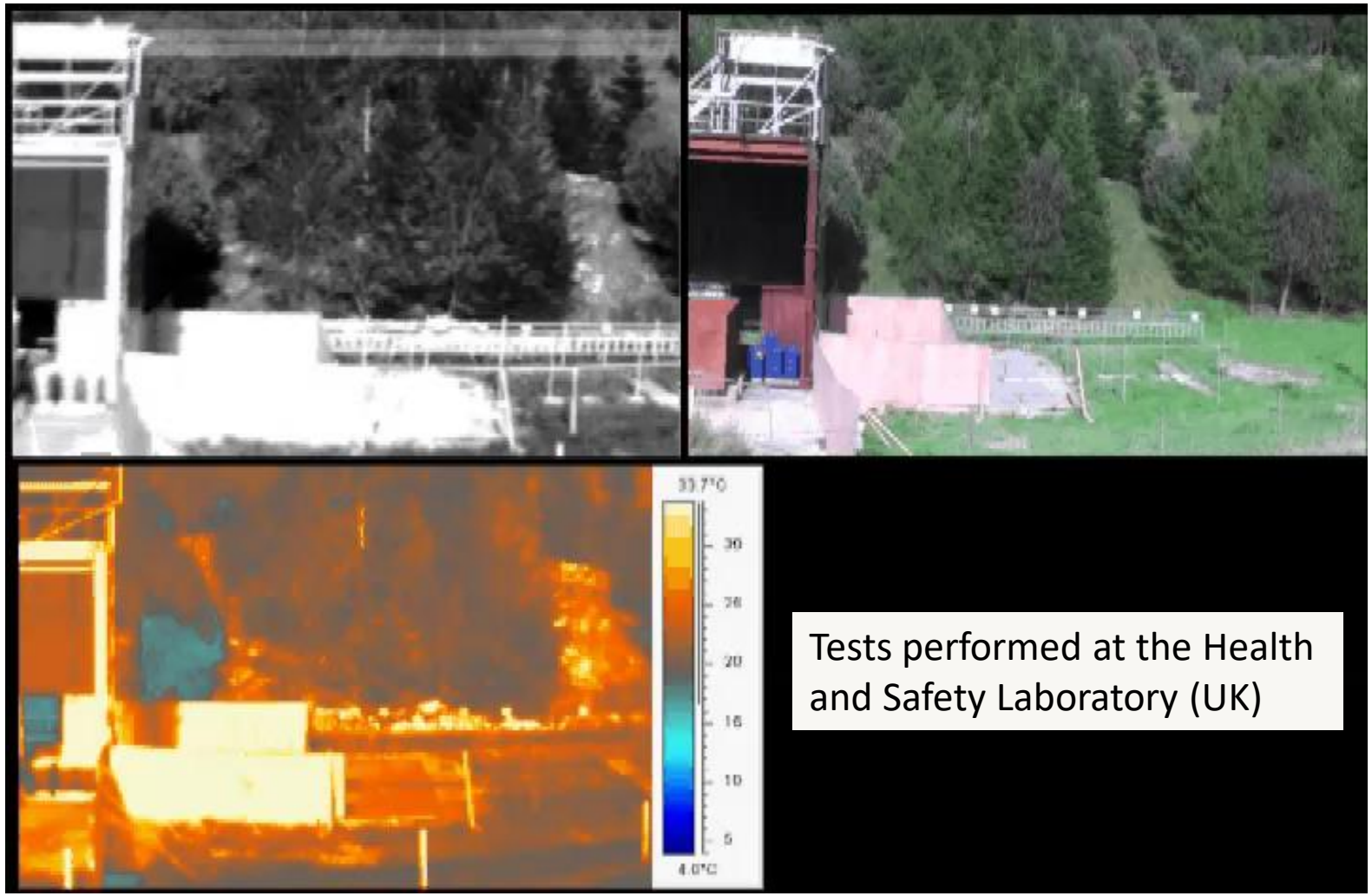


Overspill from a Gasoline Tank



Vapour Cloud Formation

- Substances
  - Hexane
  - Cyclohexane
  - Decene/butane
  - Toluene
- Front bund type
  - Vertical
  - Sloping
- Front bund distance
  - No bund
  - 5 m
  - 10 m



Tests performed at the Health and Safety Laboratory (UK)

Effect of Vegetation on Explosion Characteristics

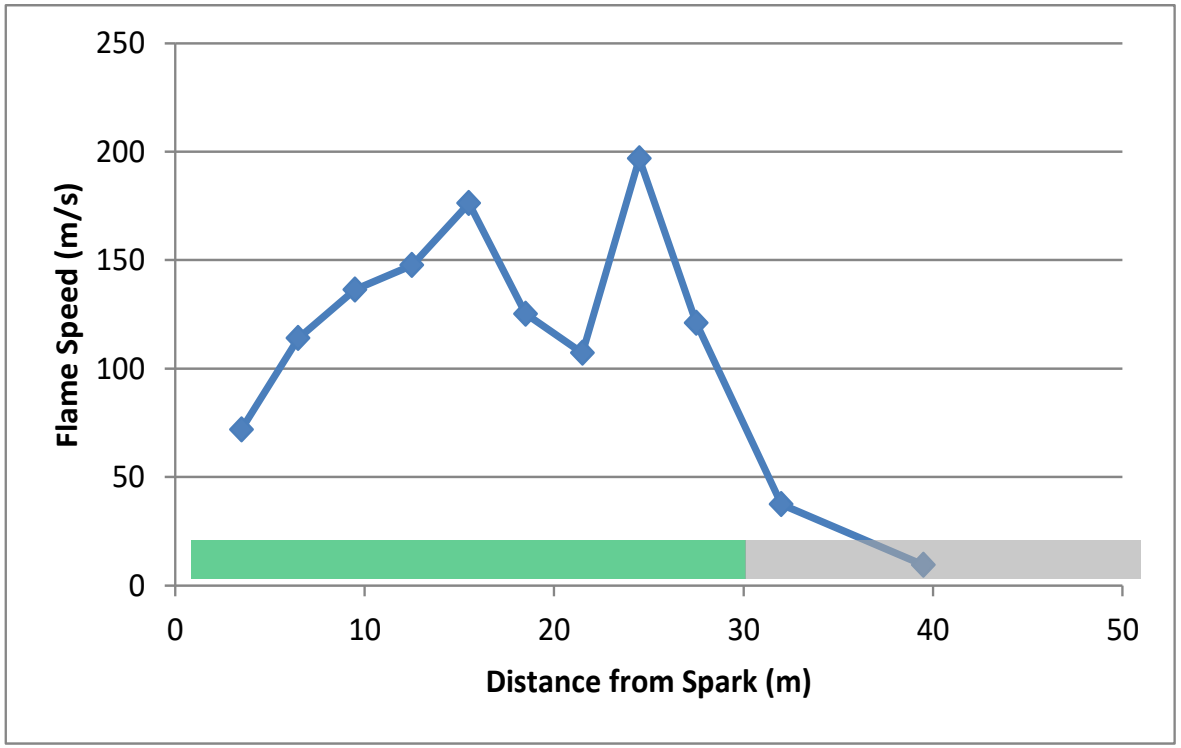
Effect of Vegetation on Explosion Characteristics

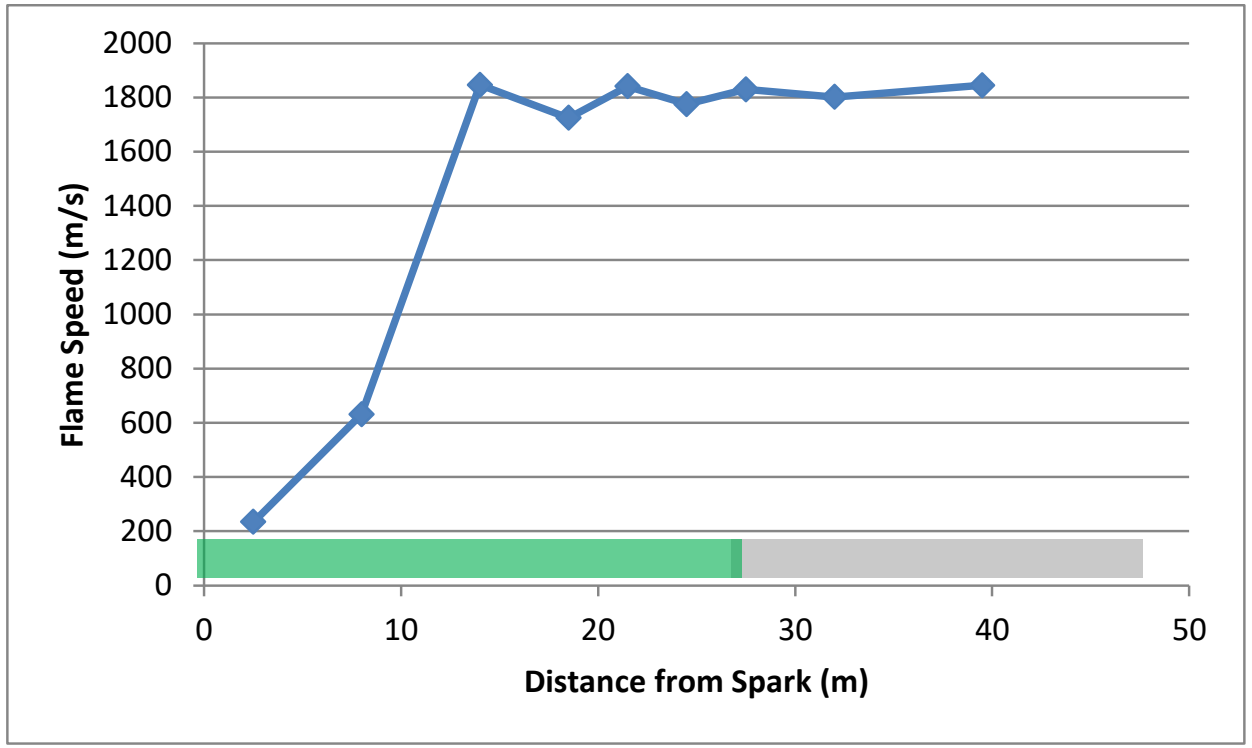
(1) Deflagration

(2) Detonation

Tests performed at Spadeadam (DNVGL)

Flame speed and behaviour





Detonation Test Objects

Damage to Objects Inside the Cloud

Detonation Test

Buncefield

Damage to Objects Inside the Cloud

Detonation Test

Jaipur

Detonation Test

Jaipur

Damage to Objects Inside the Cloud

Detonation Test

Buncefield

Buncefield – Overpressure Field

Damage to cars outside the cloud

3 bar < Pressure < 5 bar
Significant creasing to body panels

0.7 bar < Pressure < 1.1 bar
Minor creasing to body panels and broken glass

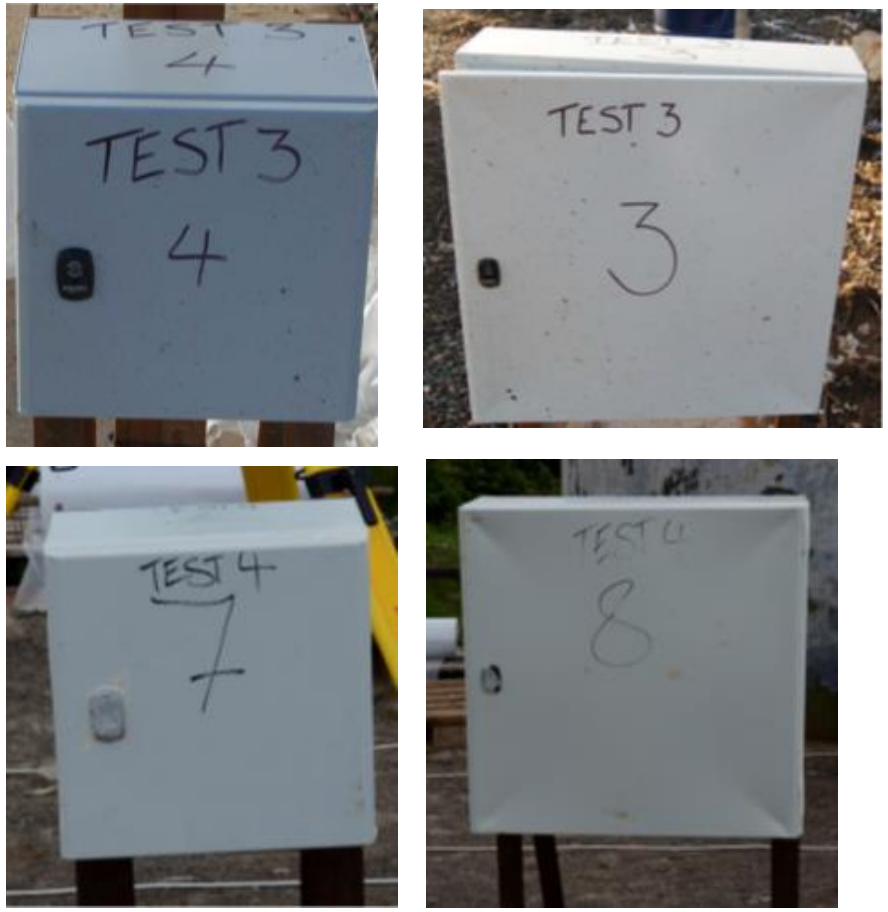
Oil Drums Outside the Cloud

Pressure ~ 3.5 bar
Minor creasing

Pressure ~ 2.0 bar
No damage

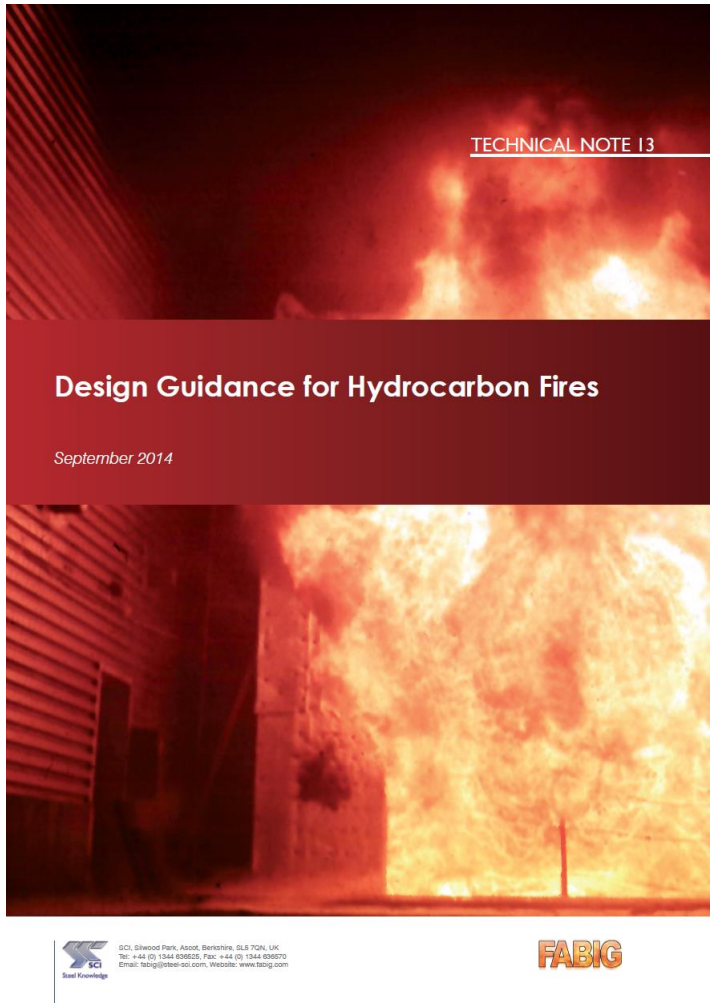
Instrument Boxes Outside the Cloud

> 3 bar – Distortion of door and sides

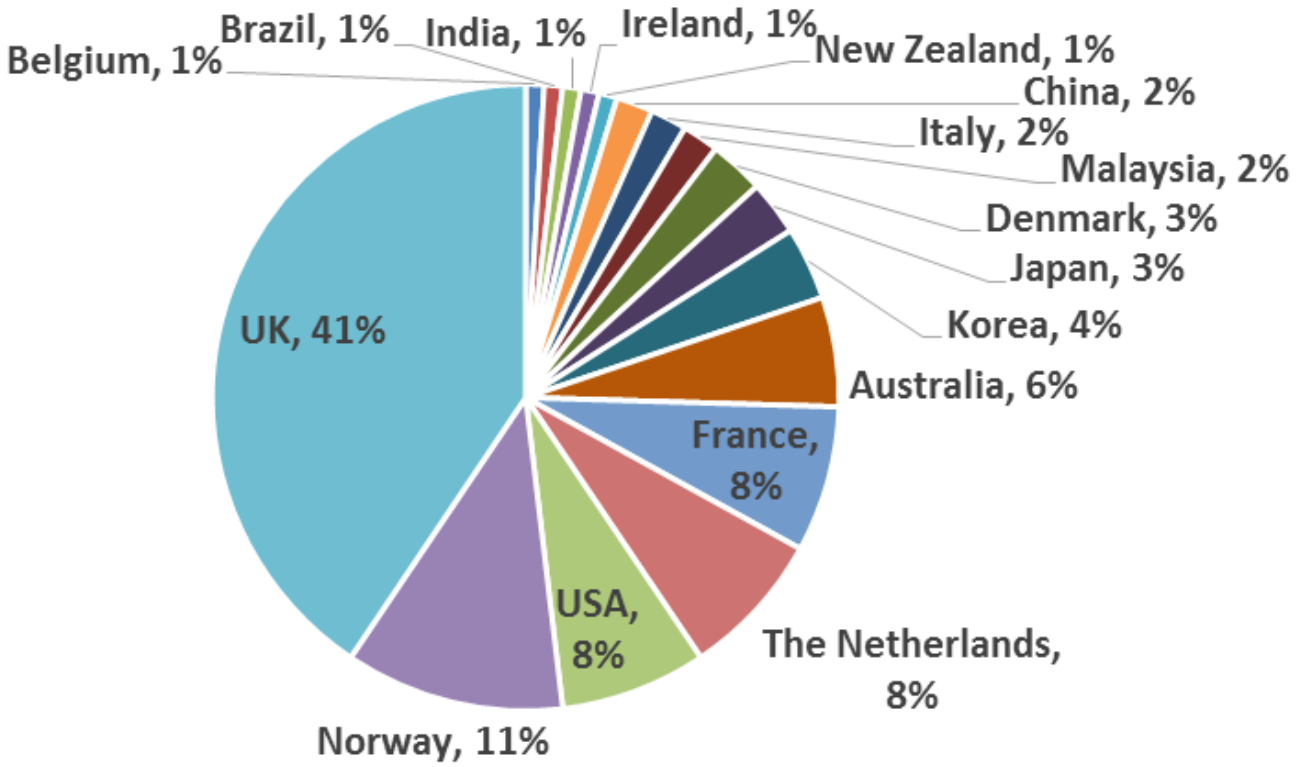


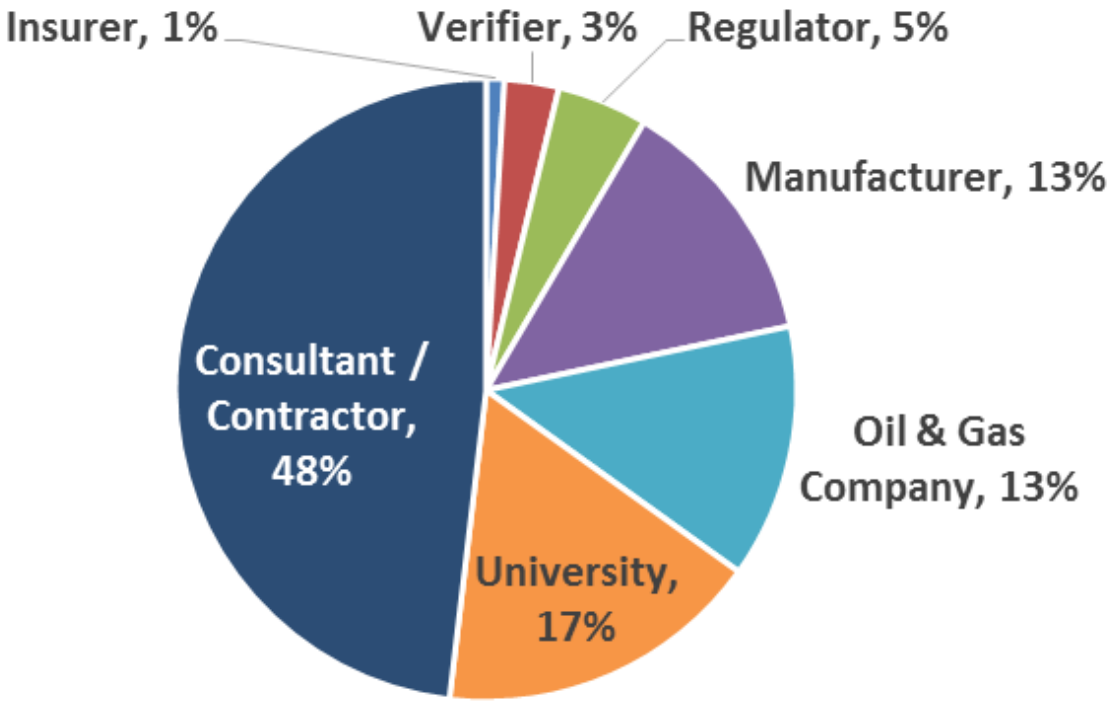
< 1 bar- No damage

FABIG Technical Notes



FABIG Membership (102 members - 2019)



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ESR Technology
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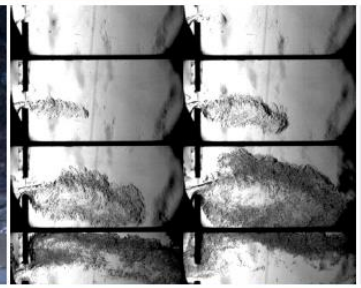

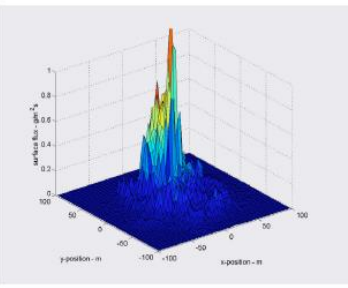

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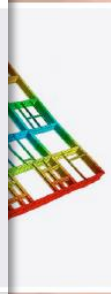

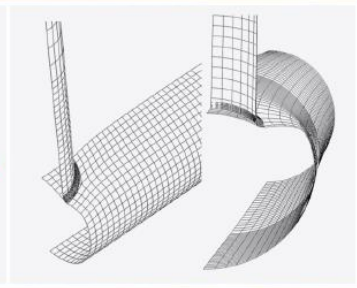

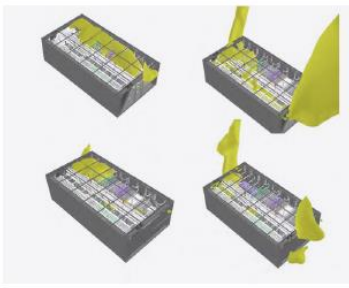

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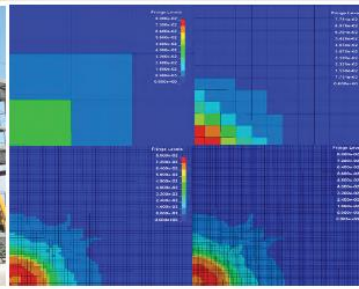

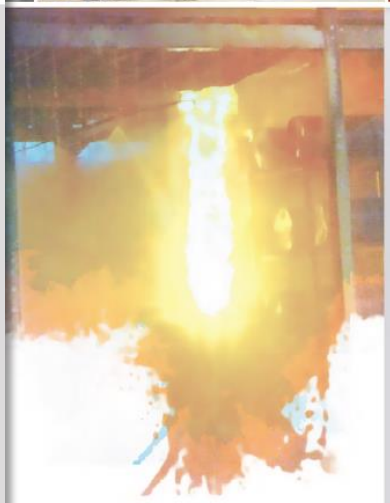

In this newsletter:

Technical Meeting – 16th December 2019 (FABIG/EPSC)

- **Temporary Refuge (TR) - Place of safety on offshore installations**
  Sumeet Pabby - Health and Safety Executive
- **Managing hydrogen sulphide (H2S) hazards in design and execution**
  Fiona Aoun – Chevron
- **H2S control and recovery barriers - PDO experience**
  Vijay Kesanakurthy & Asma Nasser Al-Harthy - Petroleum Development Oman
- **Safety operations at Covestro**
  Christian Lange - Covestro
- **Hazards and risks related to the use of hydrogen fluoride in industry**
  Dirk Roosendans - TOTAL
- **Semi-quantitative assessment of toxic hazards on chemical sites**
  Hans Schwarz - EPSC Board Member
- **Effective sheltering as part of emergency response planning**
  Robert Magraw - BakerRisk Europe
- **Using CFD to assess toxic dispersion in urban environments**
  Chris Coffey - Gexcon

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Thank you

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