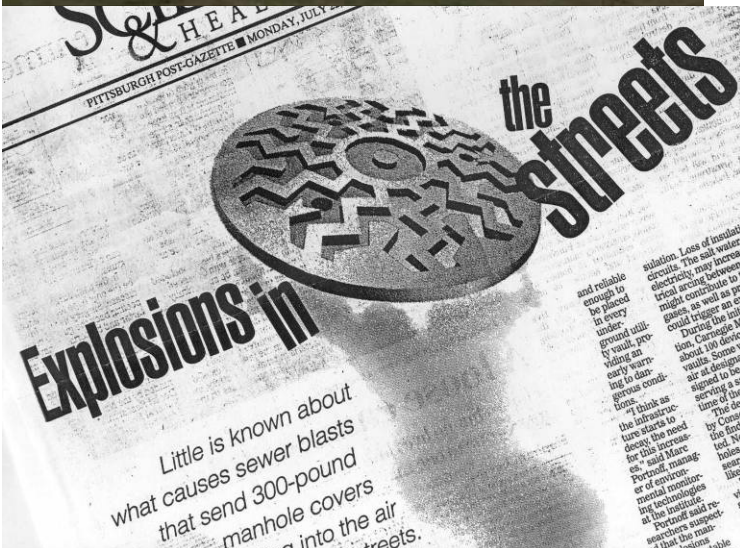




Manhole Events – State of Science of EPRI Research

Jody Lane Conference
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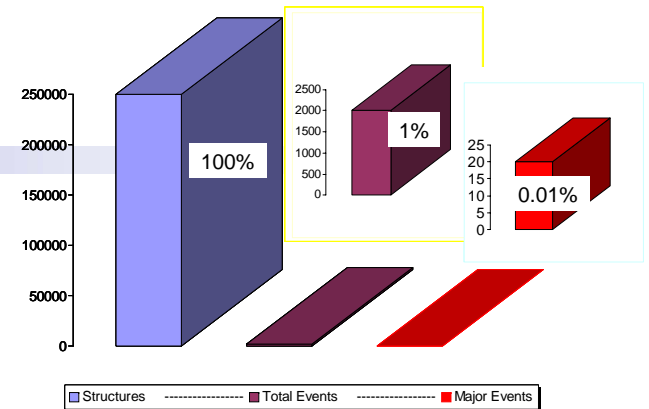
Historical Overview

- 1991 Duquesne event – fatal (not gas explosion)
- 1995 UL milestone report – composition of gases
- 1996-1998 – “standard gas explosion”
- 2000 – 2001 mitigation methods, cover types
- 2002 – State of Science workshop and report
- 2003, 2005 – Characterization round manhole of covers, restraining and locking mechanisms, composite covers
- 2006 – Rectangular covers for secondary boxes
- 2006 - 2007 – DTE and Swiveloc™ innovative pressure relief system
- 2007 – 2008 – explosion modeling, internal high-speed cameras allow viewing progress of flame front
- 2009 – test with access chimneys, measurement of gas migration between structures



What have we learned?

- Are manhole explosion events common?
Very energetic events are rare, minor events are more common.

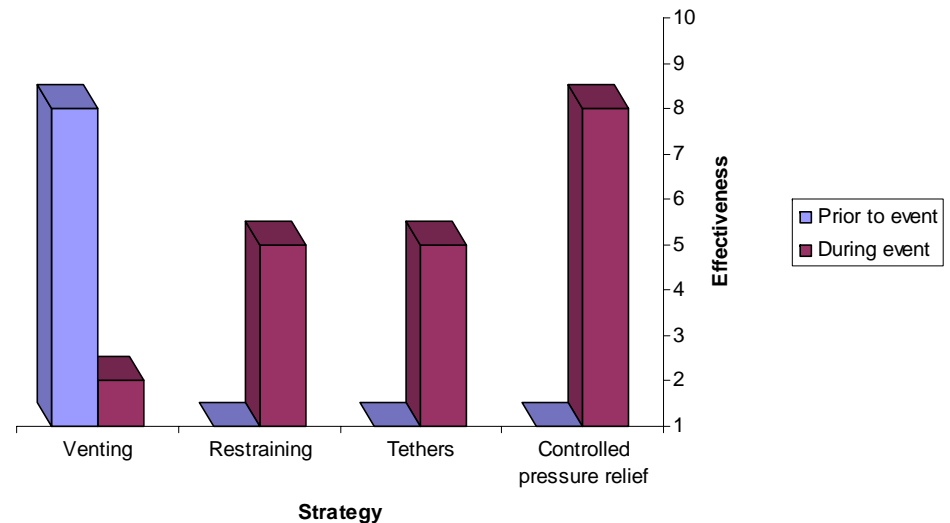


- Can events be totally prevented from occurring?
No, not at this time.
- Can covers always be prevented from being launched?
No, not at this time.

- Are vented covers better than solid covers?
“Depends”.
There is more to it than that.

- Can covers always be restrained effectively?
To some extent.

Effectiveness (1 - ineffective, 10 - fully effective)



What have we learned?

- Can pressure always be relieved effectively?
To some extent.
- Can collateral damage (road damage, internal damage) and injuries always be prevented? **To some extent.**
- Can a mitigation approach developed for one structure type be used for other structures? **No, or To some extent.**
- Does the access chimney affect the explosion event?
Yes, definitely.
- Do gases migrate from one structure to the next?
Yes, they can.
- Can several covers be dislodged in one event? **Yes.**
- Can multiple cover dislodgements be prevented? **Possibly.**



What have we learned?

- Is there room for further improvement? **Yes, definitely.**
- Are developments being made? **Yes, definitely.**
- Is there more to study/research? **Yes, definitely:**
 - Supplemental projects (test various covers, chimneys, structures)
 - Details of event dynamics
 - Effect of chimney
 - Gas migration
 - Multiple cover dislodgements
 - Minimizing collateral effects
 - Manhole entry
 - Sensors
 - Monitor new developments
 - Technology transfer

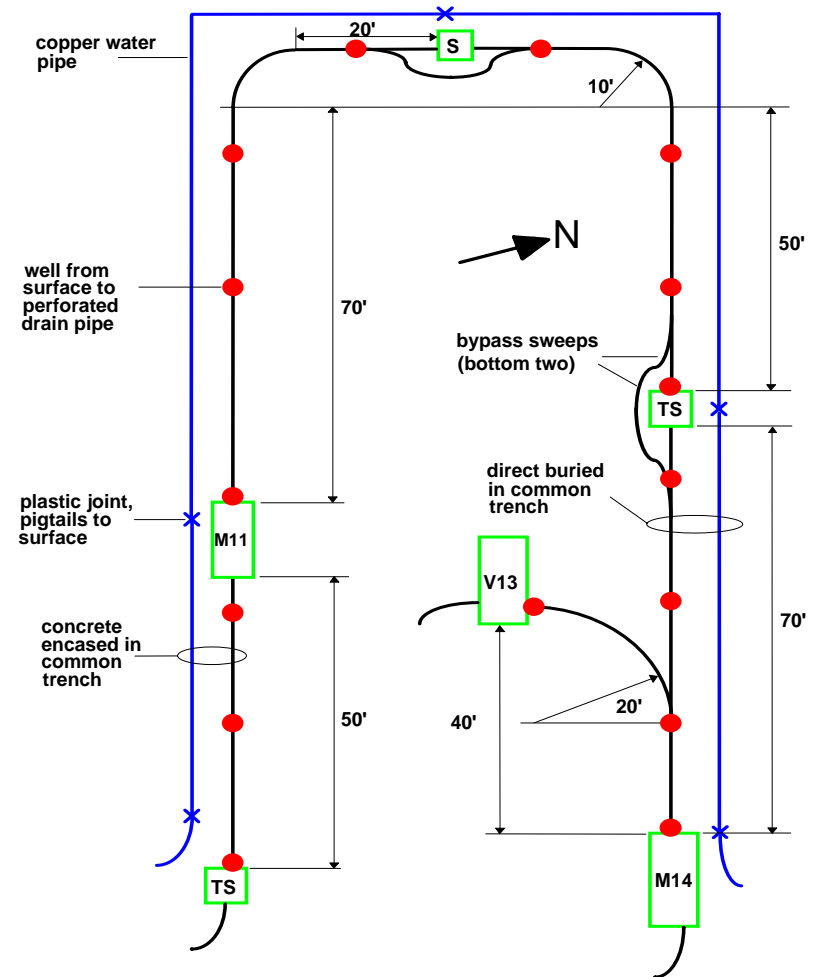


EPRI test facility in Lenox, built in 1994

- Unique facility, “one-of-a-kind”, full-scale
- Designed primarily for explosion tests
- But, flexible – can be used to represent various scenarios
- Also used for other projects: fiber-optic fault detection
- Gases:

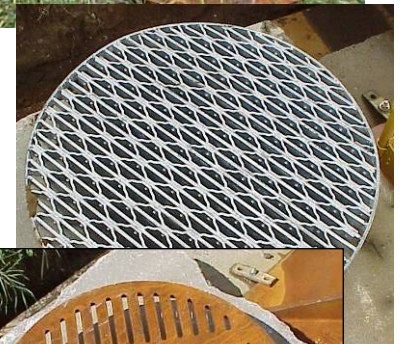
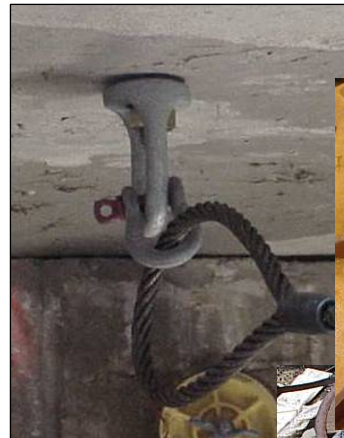
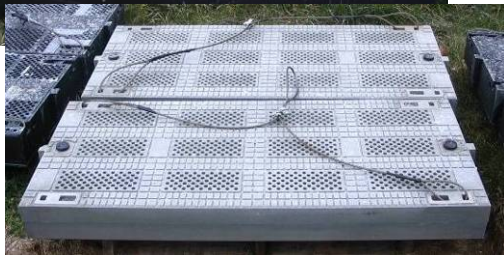
Gas	Proportion
Carbon monoxide	4 parts
Methane	1 part
Ethylene	3 parts
Acetylene	12 parts

Also
Hydrogen
and
traces of
other
gases



Cover types tested

- Solid, vented
- Iron, steel, composite
- Bare metal, coated
- Round (manhole), rectangular (secondary box)



Swiveloc cover locking/restraining mechanism – How it works (controlled pressure relief)

- Closed, engaged



- Normal – allows cover rise of @ 2"



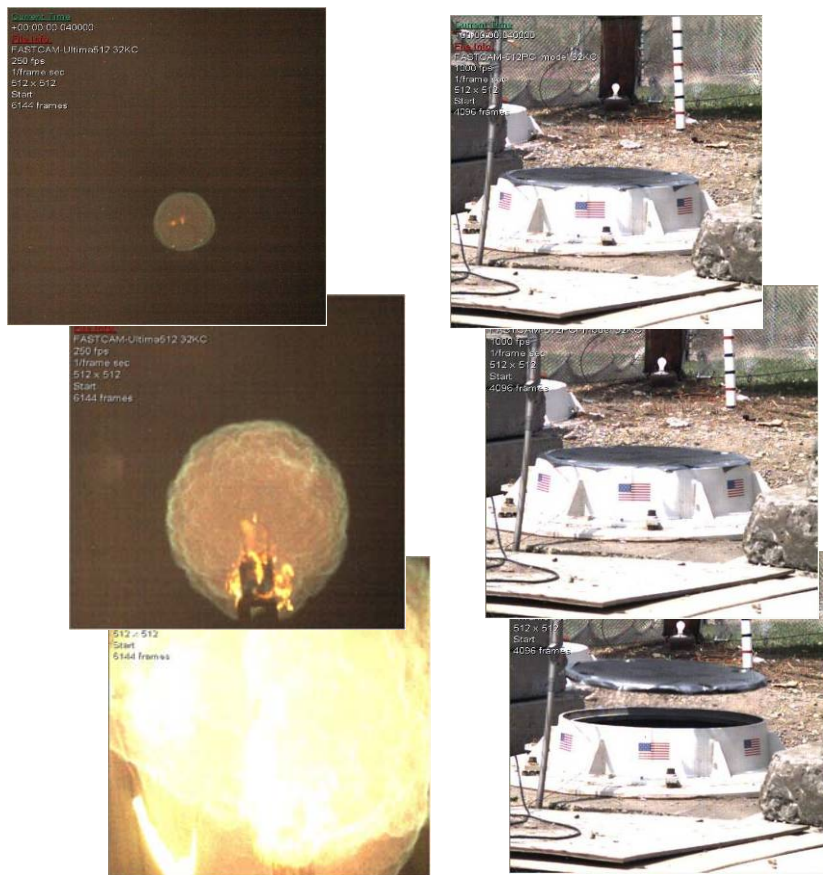
- Primary pin sheared – allows additional 1" rise



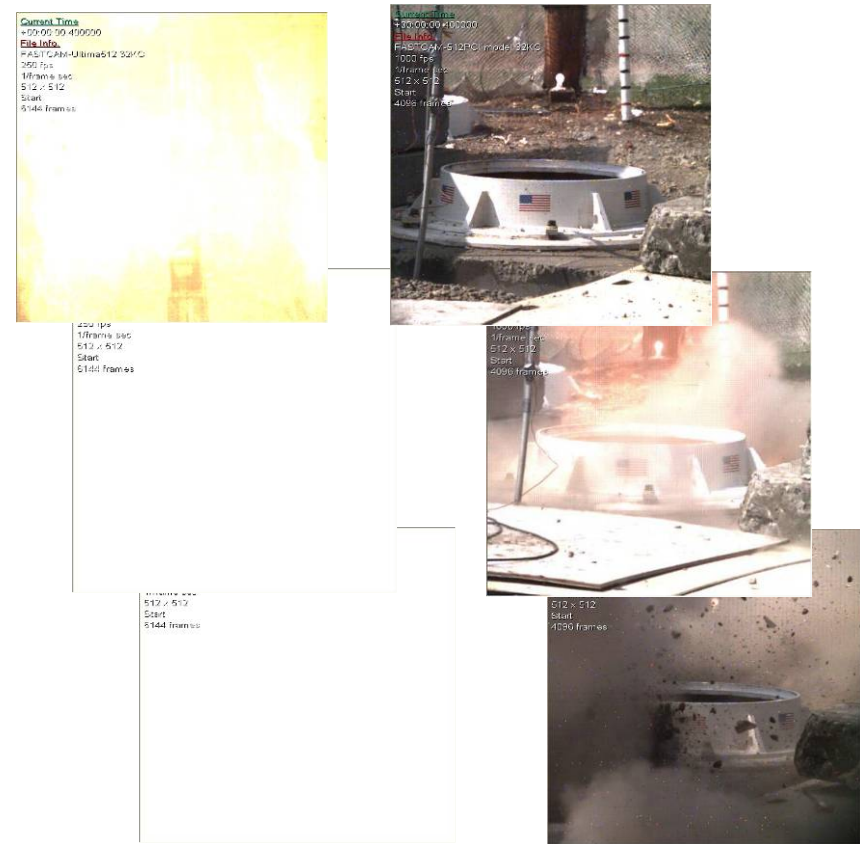
Event dynamics, “Double-Stage” Event

- Flame growth speed and Cover motion, manhole

Stage 1 (cover launched)

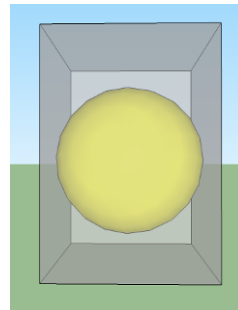
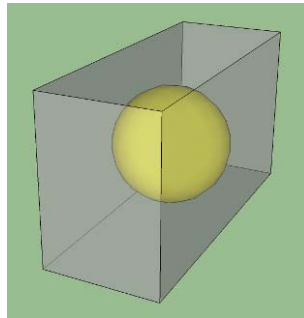
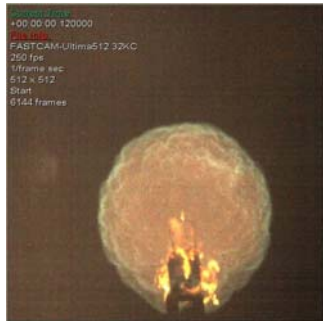


Stage 2 (roof slab launched)

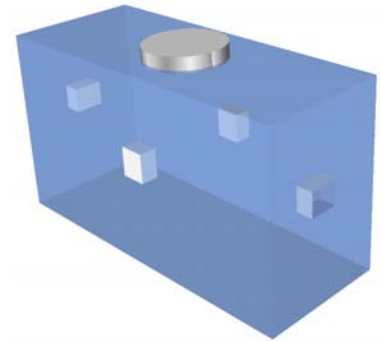


Double-Stage Explosion: Simplified mechanism – manhole vs. secondary box

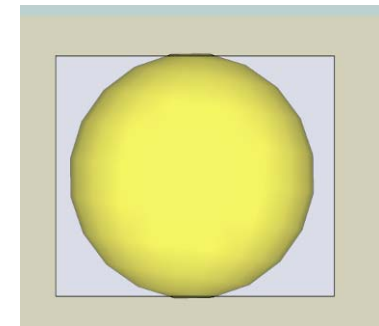
- Rectangular (elongated) manhole: flame ball expands, reaches nearest walls first
- When the flame ball reached the walls, turbulence occurs, more fuel is drawn in, and a secondary explosion occurs



At this instant, less than 1/3 of fuel has been used up

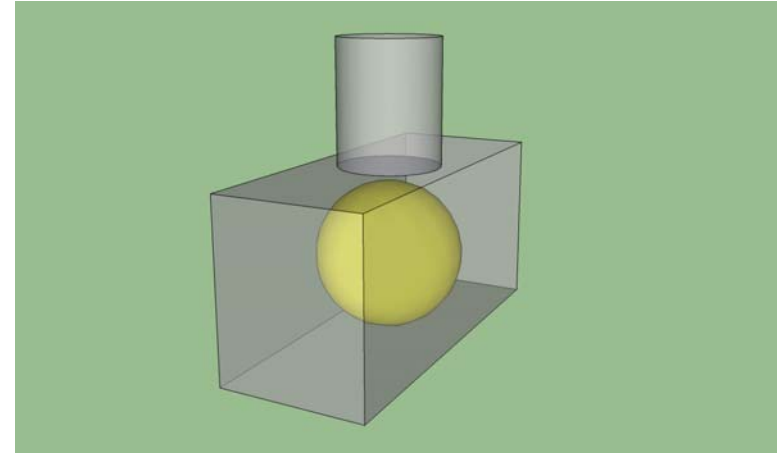


- Secondary box is nearly cubical, and flame ball reaches all walls nearly simultaneously
- “Secondary explosion” in a secondary box is very minor



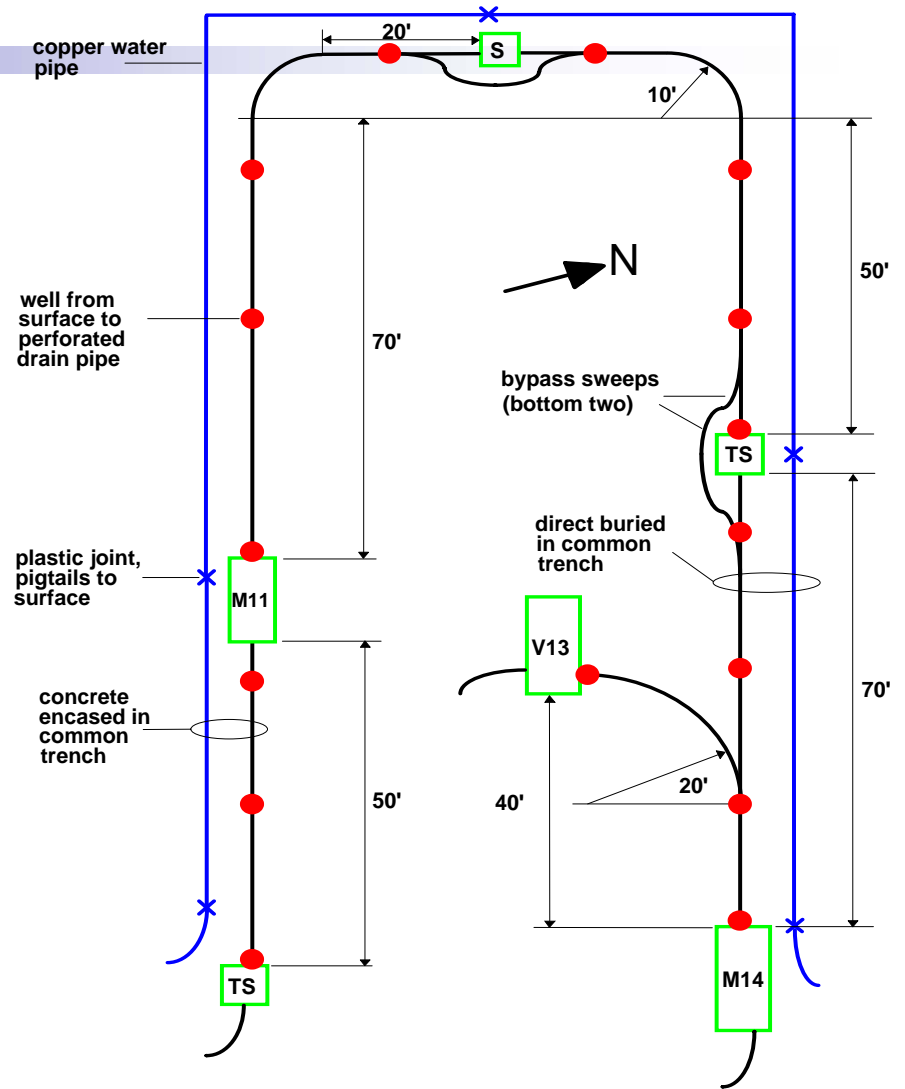
Effect of chimney

- Chimney acts like a “gun barrel”
 - Enhances gas flow rate (speed)
 - Direct flow (and pressure) upward, prevents spreading
 - Hinders pressure relief
 - Hence, cover can be launched higher for equivalent amount of fuel



Gas migration among structures

- Multiple cover dislodgements have occurred
- Preliminary results: gases migrate between structures at a rate of 0.1 to 1 ft/sec

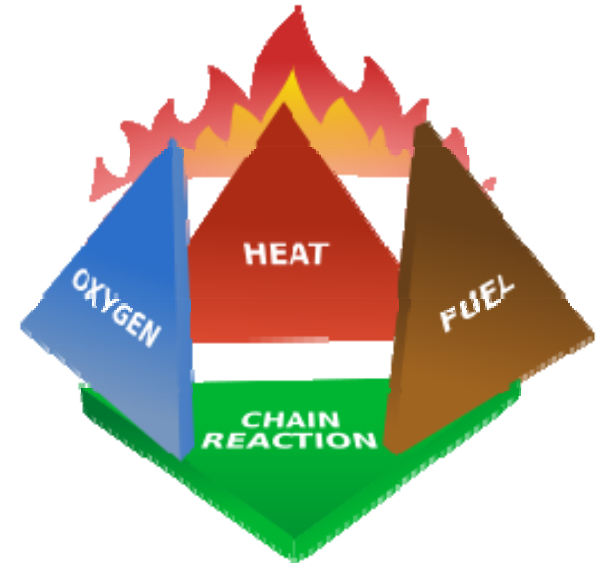


How does Stat-X work? (courtesy Fireaway LLC)



The fire triangle is a useful teaching tool, but fails to identify the 4th essential element of fire: the sustaining chemical reaction.

This led to development of the fire tetrahedron. Some fire suppression agents do not remove or reduce any of the 3 necessary components, but rather interfere with their chemical combination.



2009 Tech Update Report Outline

- Supplemental projects (test various covers, chimneys, structures)
- Details of event dynamics
- Effect of chimney
- Gas migration
- Manhole fires

