

The Risk of Flying Manhole Covers

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The Unlucky Mexican at the Wrong Place and the Wrong Time



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Monterrey, Mexico

13 Dec 2001

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- **A methane gas explosion at a manhole**

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Quirkies video report

- **The unlucky Mexican just walked on it**

- **Tossed him 25 ft into the air**

- **Hit on a overhead power cable**

- **Fell onto the roof of a passing bus**

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- **The fortunate thing was ... he was still alive**

But How about us in Hong Kong?

- OK in the past
- But
- A threatening phenomenon in recent years

Telecom Manhole Blasting at Chung On St on 12/01/2003

- 2 manholes, 8 covers
- Gas leak due to road settlement
- 4 injuries

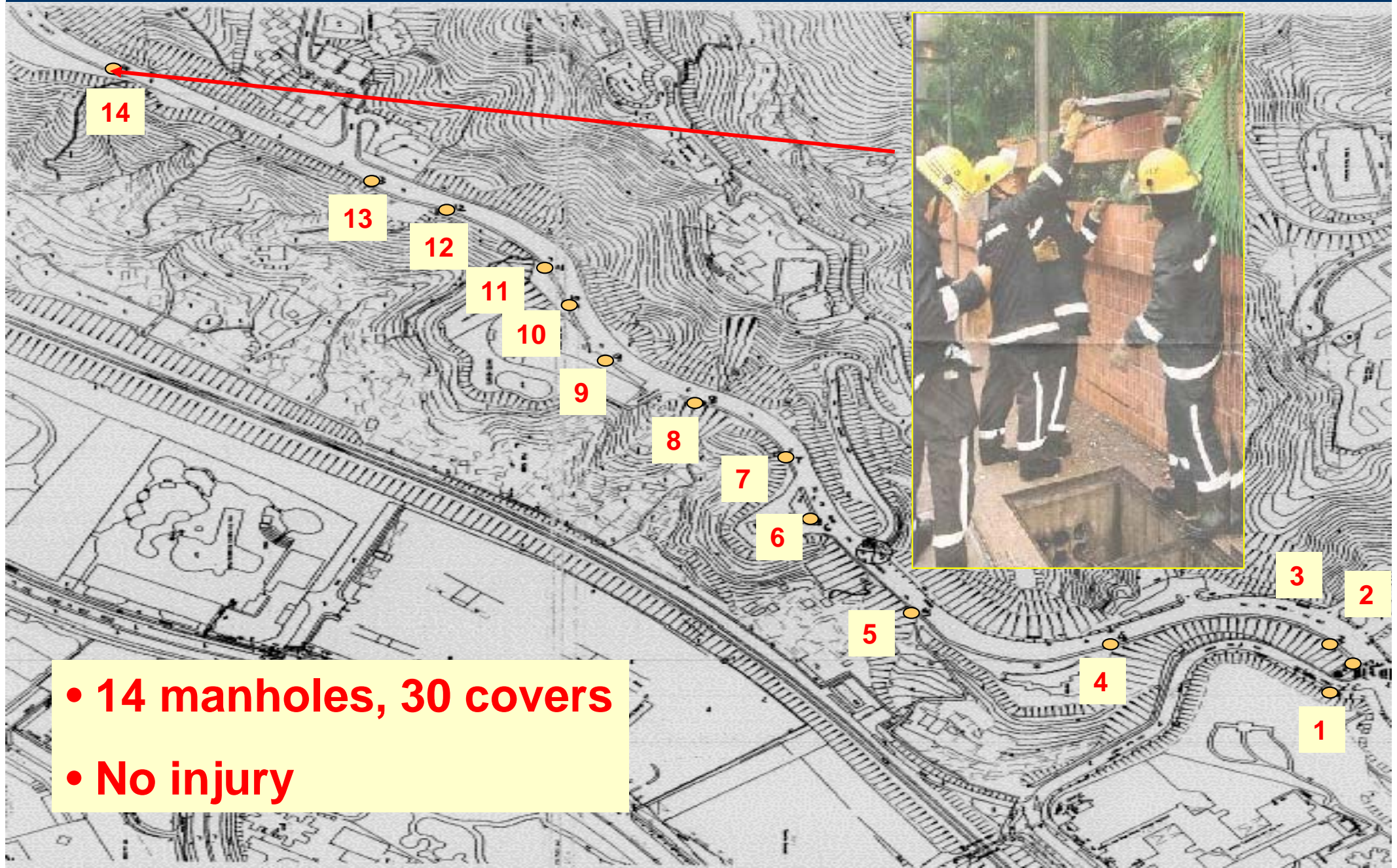


Telecom Manhole Blasting at Pokfield Rd on 13/02/2003



- 6 manholes, 14 covers
- Gas leak due to 3rd party damage
- 2 injuries

Telecom Manhole Blasting at Chik Wan St Due to Unidentified Gas on 17/04/2004



- 14 manholes, 30 covers
- No injury

Similarities of these Serious Incidents

- All telecom manholes
- All “Multi-Manhole” Explosion
- More and more serious
2 → 6 → 14 → (30 if $2X_{n-1}+2$) ??

Incidents related to other Flammable Gases in Hong Kong

港聞
A06

蘋果日報

2003-11-14

沙井爆炸渠蓋飛彈 10 米 消防員驗出含山埃毒氣

【本報訊】西環西寧街一米倉對開行人路，昨午發生污水糞便渠沙井爆炸意外，兩個三角形渠蓋被炸開，其中一個飛越兩條行車線，跌在十米外一個巴士總站站長室旁行人路，幸當時無人行經。消防員到場調查發現爆炸的糞渠沙井，除沼氣外還有山埃毒氣，懷疑有人在附近清潔時，將含有山埃的清潔劑倒落污水渠，而山埃氣體可以燃燒，不排除山埃氣與沼氣混合引起爆炸。

封路巴士須改道

由於山埃有毒需要清理，消防員曾進入附近米倉查看，並在現場向三個沙井射水及將可中和山埃的漂白水倒落渠內，至深夜仍在清理中。

發生爆炸的污水糞便渠沙井，設在西寧街十八號一個貨倉對開行人路，渠口鋪有一個半米乘半米、由兩個三角形合成的正方形鐵渠蓋組成。昨午三時許，該個沙井渠口突然傳出一聲巨響，渠蓋彈開及冒煙，其中一邊渠蓋翻跌在渠口旁，另一邊則飛越兩條行車線跌在十米外馬路，再反彈跌在巴士總站站長室對開行人路，猶幸當時無途人行經，不然可能會被渠蓋擊傷。

警方及消防員接報到場，一度以為煤氣爆炸，其後發現無煤氣洩漏後，聯同渠務署、環保署及政府化驗師在場調查，現場一段路面封閉，巴士要改道。

消防員將位於爆炸現場附近的兩個污水渠沙井渠蓋揭開，然後將探測儀器放入三個沙井內，發現沙井內俱有山埃毒氣，尤以發生爆炸的沙井山埃氣體濃度最高。據在場消防員透露，糞渠都會積聚沼氣，而爆炸通常都是沼氣造成，山埃氣體雖可以燃燒但應不會引起爆炸，至於是否山埃氣體引致沼氣爆炸，有待查驗。

清潔時倒入渠內

由於沙井驗出有山埃，消防員獲悉懷疑山埃乃由附近污水渠流至沙井，相信是有人在清潔時，將含有山埃成分的清潔劑倒入渠內，但事前又未加稀釋。

港聞
A08

明報

2003-02-13

渠蓋炸開湧白煙 行人路沙井噴沼氣爆炸

【明報專訊】葵涌青山公路行人路一個沙井，昨晨懷疑有沼氣積聚，被地底電纜產生的火花燃點，發生輕微爆炸。渠蓋被爆至揭開，冒出白煙。消防接報到場後，一度以為是煤氣洩漏引致意外，通知各相關部門封鎖行人路仔細調查。事件中無人受傷。

燃點電纜火花

現場葵涌青山公路547至549號瑞康工業大廈對出行人路，上址行人稀少，100米外有一個油站。發生爆炸的沙井面積30乘20厘米，深30厘米，內有中電的電纜及電訊盈科的電話線。該段10米長的行人路上，共有7個同類型沙井。

昨晨11時38分，其中一個沙井突然傳出巨響，渠蓋彈開，有小量火花及白煙冒出，途人見狀報警。

疑泄煤氣封路調查

消防接報到場，將一段行人路封鎖調查，發現渠蓋被熏黑，揭開後不斷冒出白煙，但並無起火。消防用氣體探測儀器，深入沙井探測，初步相信是氣體爆炸，一度懷疑泄漏煤氣，於是通知中電、煤氣公司及政府化驗師等到場協助調查。

其後，消防將附近渠蓋全部揭開，探測氣體來源。政府化驗師證實，引起爆炸的不是煤氣，而是沼氣。由於證實現場再無危險，道路於下午1時許解封。中電人員其後鑿開沙井，證實電纜是否有問題。

葵涌消防局長鄧有年表示，沼氣並不罕見，初步相信沙井內積沼氣，而沙井內有電纜及電話線，有可能是電纜或電話線的中途掣或接駁器冒出火花，燃點沼氣引致爆炸。

14/11/2003

Chemical

13/02/2003

Sewer Gas

8

7-Manhole Explosion in Japan Due to Gasoline on 5/10/2001

Explosion blows manhole cover into school window

YAWATA, Kyoto -- An explosion broke out underground in a residential area here Friday, sending up a pillar of fire and blowing manhole-cover fragments into a local school window, police said.

A resident called fire services at about 4 a.m. Friday after hearing an explosion and seeing a pillar of fire and smoke erupt from a manhole on the street.

Police who rushed to the scene found that **seven manholes** within the grounds of a local school had been blown out of place. Fragments from one of them were blown 17 meters away smashing a window at the school. No one was injured.

Investigations were continuing into the cause of the explosion police said, adding that the smell of gasoline was detected in a gutter in the area.

Police added that a **gasoline** can had been stolen from an emergency-equipment storage room nearby. (Mainichi Shimbun, October 5, 2001)

<http://mdn.mainichi.co.jp/news/archive/200110/05/20011005p2a00m0fp011001c.html>

Telecom Manhole Explosion in Singapore Due to Unknown Gas on 17/12/2004



CHANNEL NEWSASIA

Gas build-up causes 7 manholes along Changi Rd to pop up

17 December 2004

01:22

[Channel NewsAsia](#)

English

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SINGAPORE : A gas build-up blew off seven manholes along Changi Road on Friday.

At about 5.30pm, the telecommunication manholes along the extreme left lane of Changi Road towards Geylang, literally popped out five metres away from its position.

Each weighs some 200 kilogrammes, and it would have taken several men with tools just to remove it.

Though the incident happened during peak hour, it was fortunate no one was injured.

SingTel engineers inspected the affected manholes and confirmed the incident resulted from a gas build-up.

The manholes were checked for gas leaks, but only one showed a high level of carbon dioxide, which engineers say builds up naturally over a long period of time.

SingTel says though such blow outs are common, what's unusual is seven covers being blown out at the same time.

Other agencies, like the PUB, were also present to conduct further investigations.

By 7.30pm, six of the affected manholes had already been covered, except for one which is badly damaged.

Manhole Explosion in Shenzhen, China on 11/05/2005

深圳煤气泄漏引发爆燃 “大胆”市民看热闹遭殃



Damage to underground LPG pipe

本报深圳今日电（记者于明山）昨日0时10分左右，深圳市深南大道与华富路附近，一施工单位在修建地下通道时违章施工，造成直径110毫米的地下燃气管道泄漏引起爆炸。事故中1人死亡，16人受伤。在16名伤员中，有6名围观者，唯一死亡的女性也被判断为围观市民。

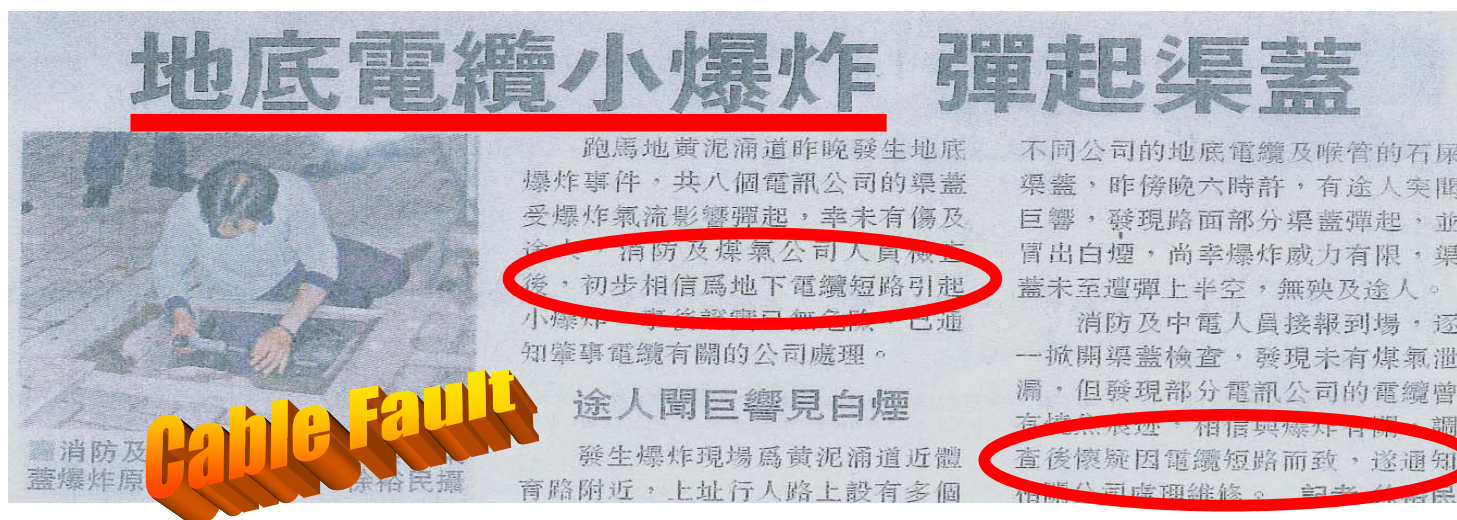
A flying cover hit a passer-by and killed her instantly



The escaped LPG entered into the nearby ducts, manholes and cable troughs resulting in a number of **cascaded explosion** blowing up the covers

Power Cables could also Cause Manhole Explosion

Suspected Power cable fault created air pressure or evolution of combustible gas and led to explosion.



1/08/2005

Leighton Road

Power Cables could also Cause Manhole Explosion



Suspected Power cable fault generated combustible gas and caused explosion after triggering by ignition sources.

四渠蓋彈起 濃煙湧入酒樓三層樓 地底爆電纜嚇走300食客

20/11/2005

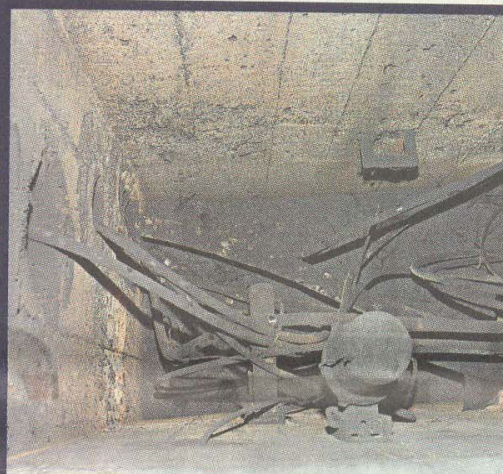
Prince Edward Road West

Cable Fault

九龍城地底電纜爆炸
示意圖



地底電纜爆炸將渠蓋彈起，大量濃煙從渠口冒出湧入酒樓，數百食客紛紛走避，五名酒樓職員吸入濃煙不適



發生爆炸的地底電纜被火熏黑。

【本報訊】九龍城太子道西一間酒樓對開一條地底電纜，昨晚突然發出爆炸巨響，將地面四個渠蓋彈起，火燄燒着電纜膠皮導致大量濃煙冒出湧入酒樓內，三百多名食客以為酒樓發生火警，紛紛走避逃生。事件中，六名酒樓職員吸入濃煙不適，須送院治理，幸無大礙。消防員到場用滅火筒射向渠內，迅速將火撲熄，調查電纜爆炸原因。

六職員吸濃煙不適

現場是九龍城太子道西四〇四號近衙前望道的又一多酒樓，昨晚八時許，突然有人聽聞一聲爆炸聲響，繼而見酒樓門口一個四呎乘兩呎的石屎渠蓋應聲彈起約半呎高，原本放置在渠蓋面的一個酒樓玻璃廣告牌隨之翻倒地上，玻璃碎片四濺；另外不遠處三個兩呎乘兩呎的渠蓋亦相繼彈起，幸當時行人路上途人不多，沒有傷及路過人士。

在爆炸發生後，懷疑渠底的電纜膠皮被燒着，長時間，大量濃煙從彈起渠蓋的空隙不斷冒出，濃煙湧入酒樓內，由於時值晚飯時間，佔地三層的酒樓，一樓、二樓及三樓各層都高朋滿座，其中三樓更有兩批賓客正在

Electrical Manhole Explosion is not UNCOMMON in the U.S.

[Power restored after small explosion in Berkeley; driver hurt](#)

- Bay City News

Monday, September 19, 2005

September 19, 2005

Berkeley -- Power was restored to 2,200 Pacific Gas and Electric Co. customers in Berkeley about two hours after an underground connection splice failure sent a manhole cover into the air today.

The explosion occurred on Bancroft Way near Telegraph Avenue around 2:30 p.m., according to the Berkeley Fire Department.

PG&E spokesman Jeff Smith said the cable splice failure caused what the utility company calls a "concussion."

"That concussion pushed the manhole cover up," Smith said.

When the manhole cover came down, it collided with a Mercedes Benz 190 and the car's air bag deployed, striking the driver in the upper body and causing minor injuries, according to the Fire Department.

© Aug 19, 2005 10:12 am US/Pacific

Explosion In PG&E Vault Rocks Downtow



Joe Vazquez
Reporting

(CBS 5) SAN FRANCISCO An explosion in an underground PG&E utility chamber in downtown San Francisco sent manhole covers flying, shattered store windows, and started fires Friday. Two people were injured.

The blast struck at the intersection of Post and Kearny about 10am, buckling a section of the sidewalk. The explosion ignited the awning of the Ralph Lauren store on Post, and broke its

Berkeley
19 Sep 05

*An
underground
connection
splice failure
sent a
manhole
cover into
the air.*

WTNR-TV—Indianapolis, IN

• MAKE THIS YOUR LOCAL NEWS

TOP STORIES



FROM:

For fourth time, explosion blows out manhole cover

WTNR-TV

Steve Jefferson/Eyewitness News

Indianapolis, Sept. 6 - A downtown manhole explosion caught Indianapolis firefighters by surprise Monday night. A spokesperson said one of IPL's primary underground cables went bad, contact with a secondary cable lead to deterioration and then fire.

The underground pressure from the buildup forced the manhole cover into the air. Then there was a smaller flare-up a few feet away at

Indianapolis, 6 Sep 05

underground cables went bad, The underground pressure from the buildup forced the manhole cover into the air.

San Francisco, 19 Aug 05

An explosion in an underground utility chamber in downtown San Francisco sent manholes cover flying ...

Pyrolysis - Formation of combustible gases when cable sheath melts at high temperature and anaerobic condition

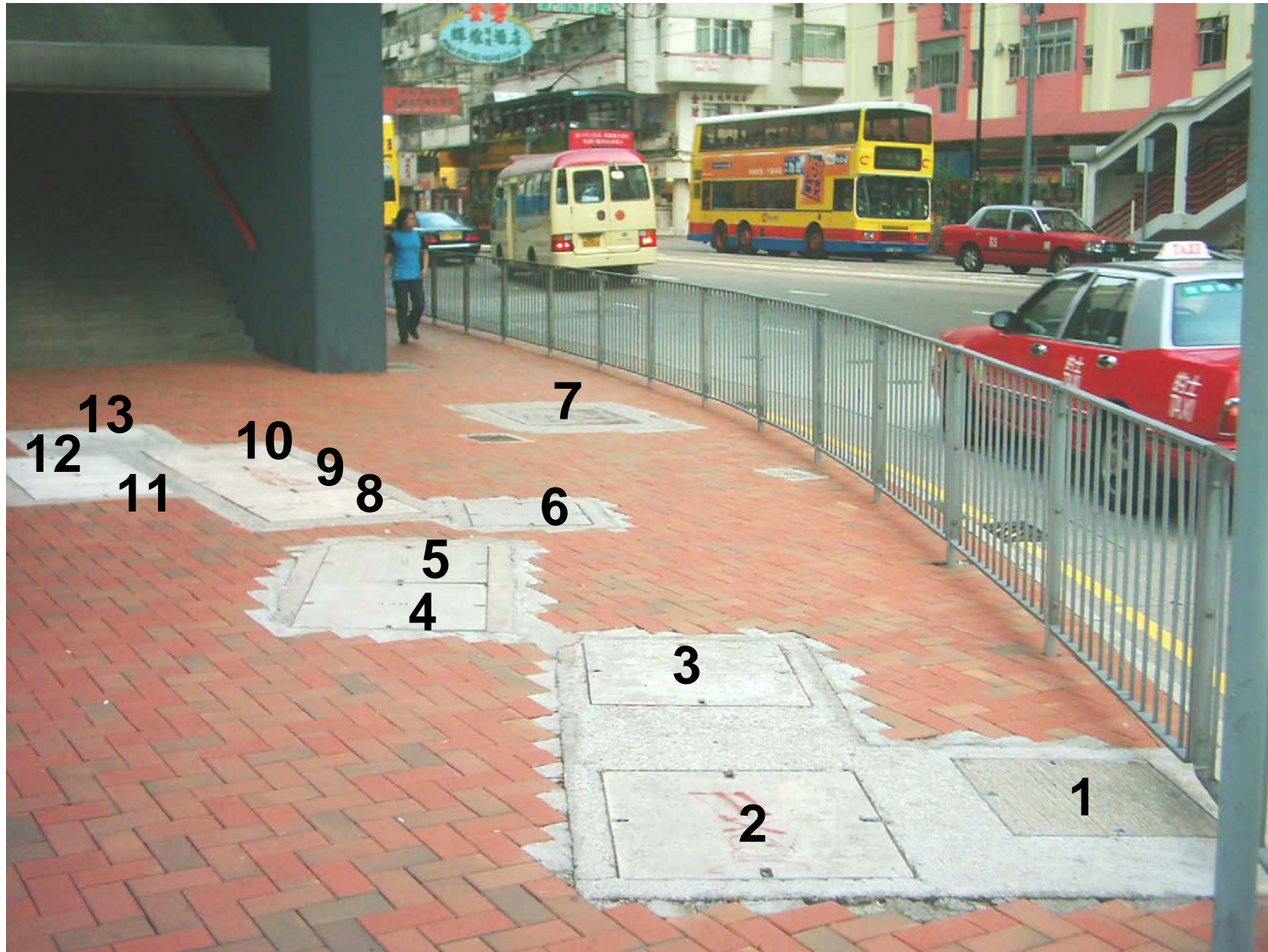
Why Bother?

- Hong Kong is just too congested.
 - too many people on the ground
 - too many underground ducts
 - too many manholes
- A single manhole explosion could injury a dozen.

AND

- The risk of multi-manhole explosion is too high!

How Many Covers Can You Find?



What Went Wrong?

Hostile & Irresponsible Type of Criticism →
“No Leak, No Explosion!”

Reality:

- Not only piped gas – LPG, Sewages, Illegal disposed chemical, gas generated from electricity fault.
- 3rd party damage and external disturbances.

What has the Gas Company done?

- Replaced all cast iron mains
 - Probably the only gas company > 30 years old had no C.I. mains
- Reduced 3rd Party Damage
 - 80% ↓ vs 1997
- Enhanced leakage survey
 - 1 per year → 3 per year

But

It is not possible to eliminate all possibilities of gas leak

What Really Went Wrong?

- Congested Underground Facilities.
- Dramatic Increase of Utilities
e.g. Liberalization of Telecom Market: 1 → 10+
Hong Kong is unique !
- No orderly disposition rules.
- Increased Road Work Activities → damage to underground facilities such as fragile PVC ducts left unaware.

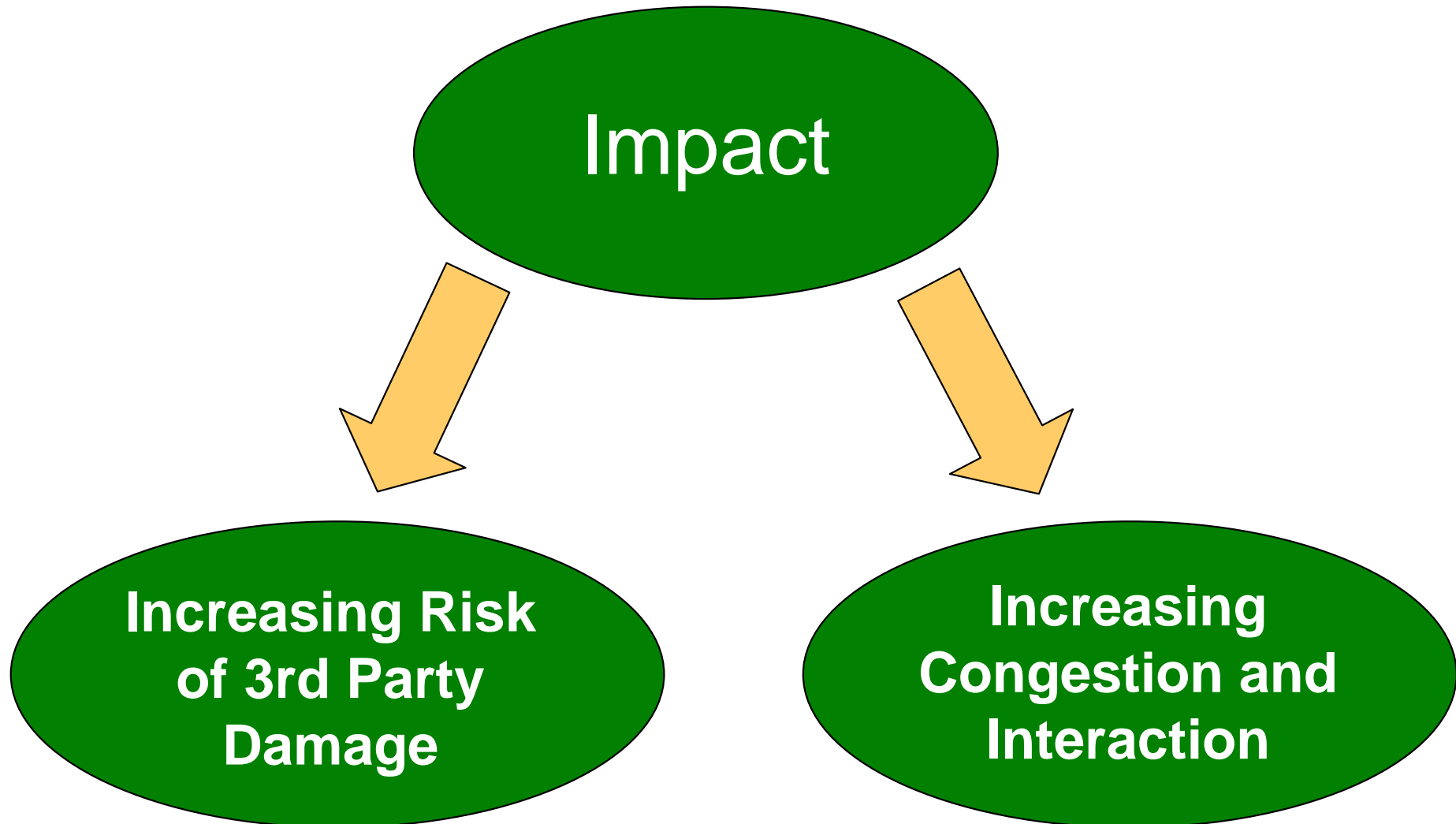
Characteristics of a Rapidly Developing Metropolitan City

Year	1984	2004
Population	5.4M	6.9M (+28%)
Permanent Quarters	1.5M	2.4M (+60%)
Length of Roads	1,279km	1,943km (+52%)
Electricity Consumption	56,829TJ	152,313TJ (+168%)
Gas Consumption	6,907TJ	27,137TJ (+293%)
Internet Cyber Traffic Volume	None	3.0M Terabits (roughly 3-4 fold a year)
U/G Utility Undertakings	7	17 (+143%)

BUT

- **No increase in pavement width (3.5m max. typically even in new town)**
- **No orderly disposition rules for U/G utilities**

Characteristics of a Rapidly Developing Metropolitan City



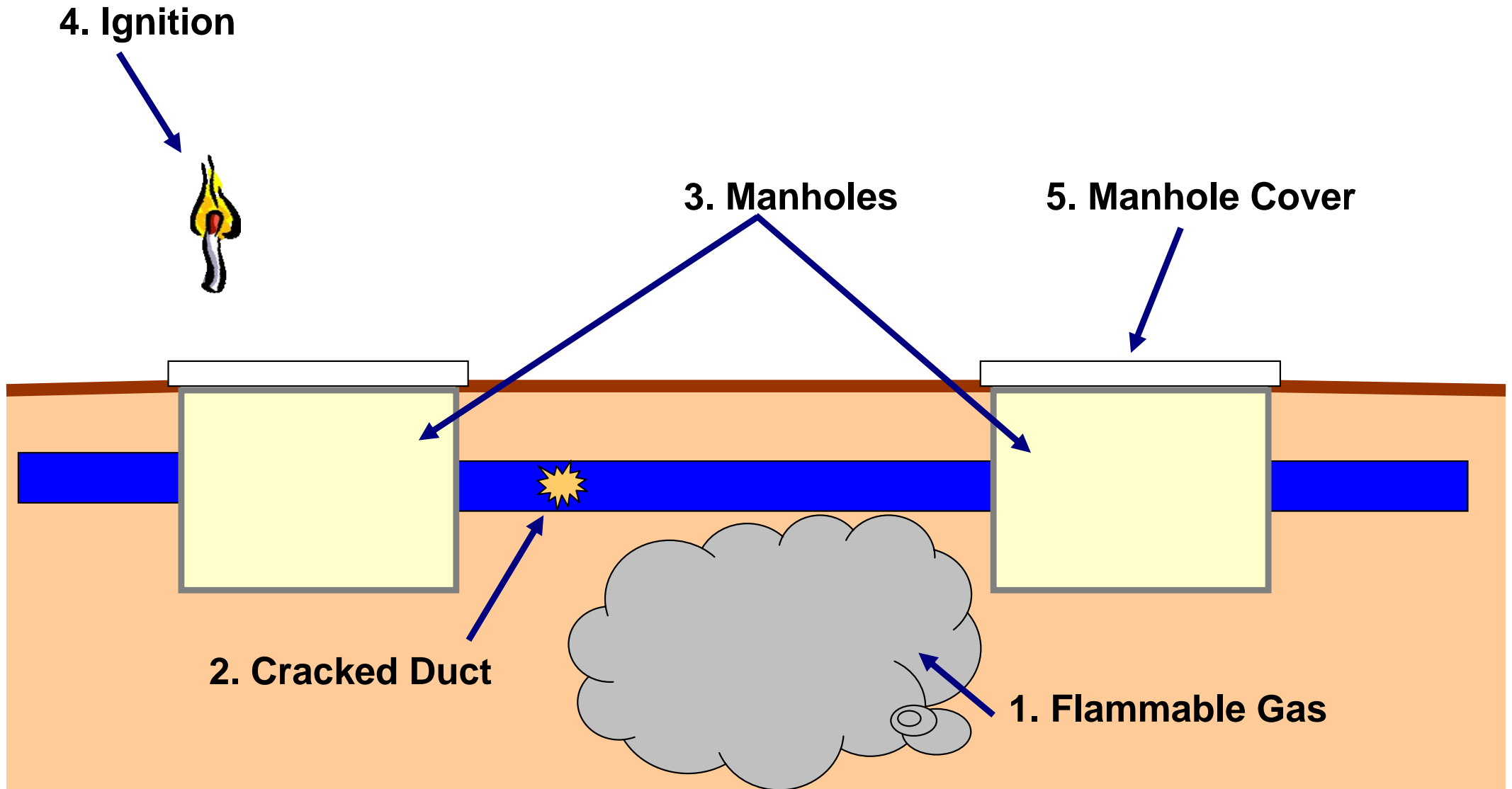
Spaghetti at Construction Sites



Cracks or Holes at Ducts in HK



5 Elements of Typical Flying Manhole Cover Incident



Means to Eliminate Flying Manhole Cover

- **Flammable Gas**

- Various types of gas? 3rd party damage? External disturbances and road settlement?

- **Ignition**

- Unpredictable. Too many potential sources

- **Enhance Integrity of Underground PVC Ducts**

- Remove cracks/holes on fragile ducts? Use stronger ducting, e.g. PE? Too costly? How about those already installed?



- **Modify Manhole Design**

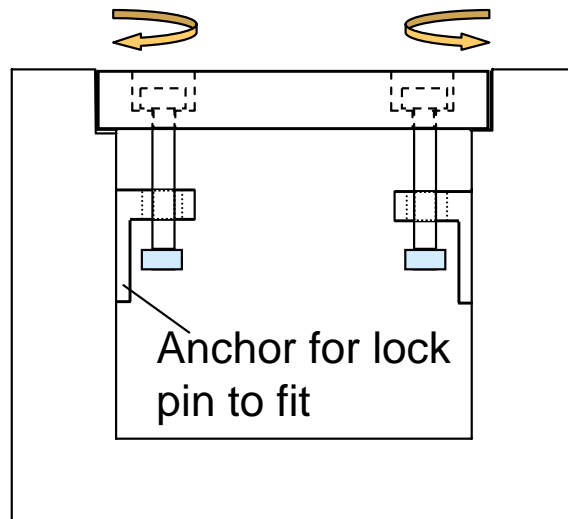
- Venting
- Mechanical Restraint
- Eliminate / Reduce Explosive Volume
- Duct Sealing

Venting – Perforated Manhole Cover

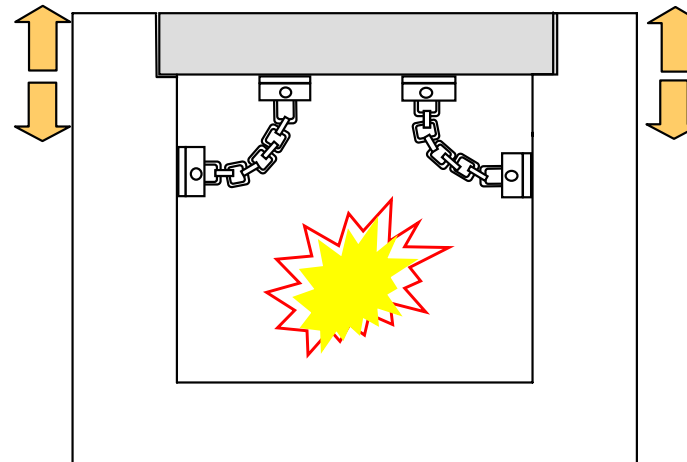


- Vent size – too small? too big?
- Rainwater, trash or even ignition sources?
- Hygiene
- Huge cost for modification?

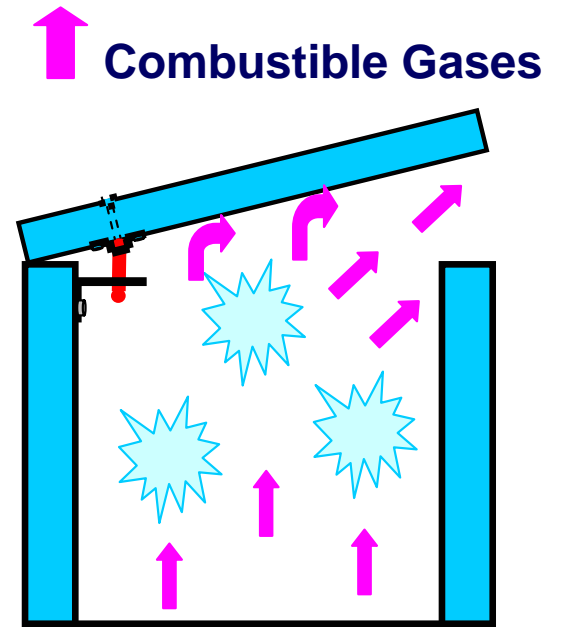
Mechanical Restraint



Mechanical Lock



Metallic Chains



Hinged Cover

- Long term integrity
- Not eliminate problem – Explosion still occurs!
- Huge cost for modification

Testing of Mechanical Restraint Design



Volume (Energy) Reduction



Sand Bags



Water / Air Bags



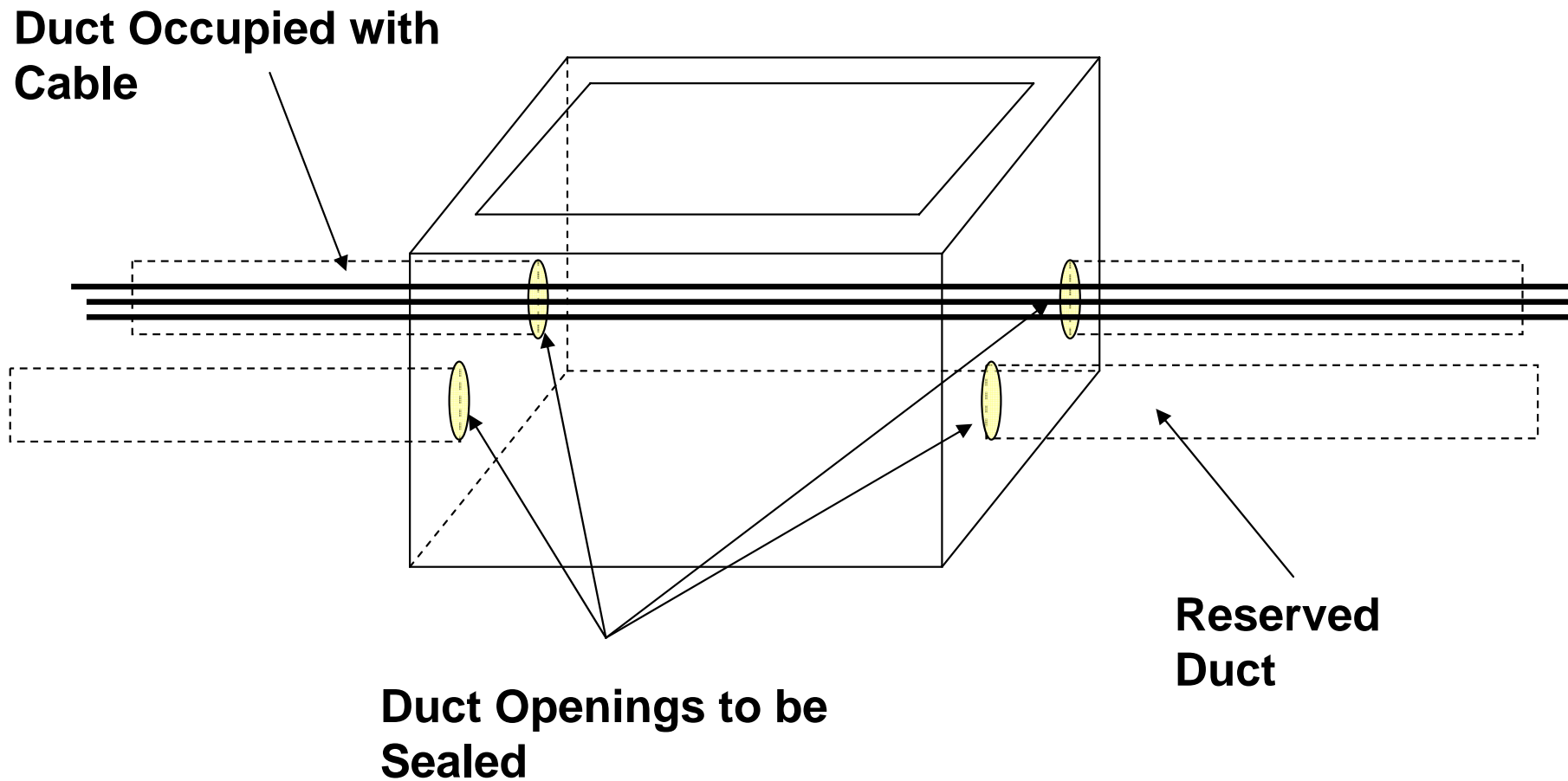
Foam Materials

- Hindrance to future maintenance
- Long term integrity - Deflation of Bag

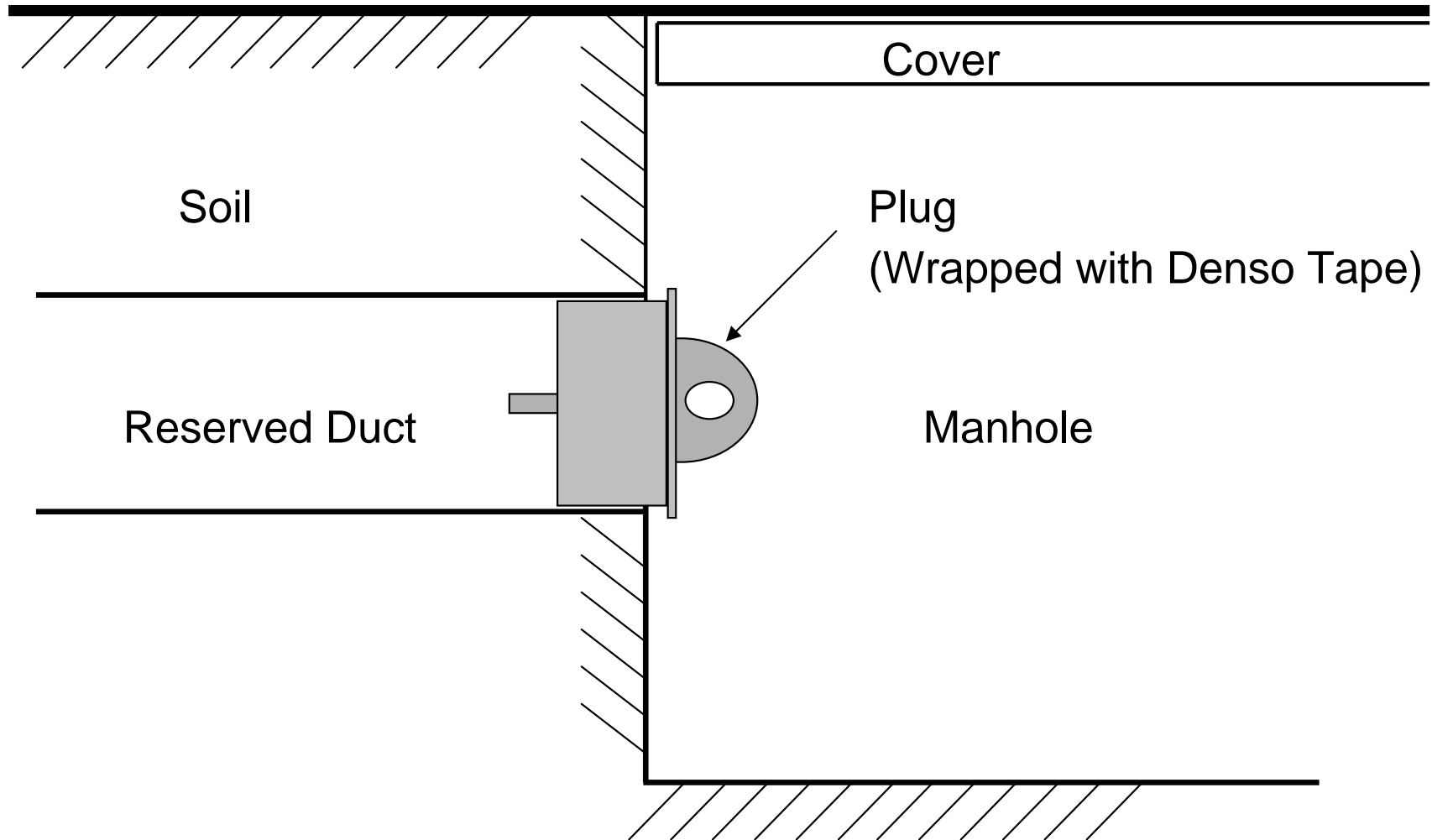
Testing of Volume Reduction Design



Duct Sealing



Sealing of Reserved Ducts by Blank Plug

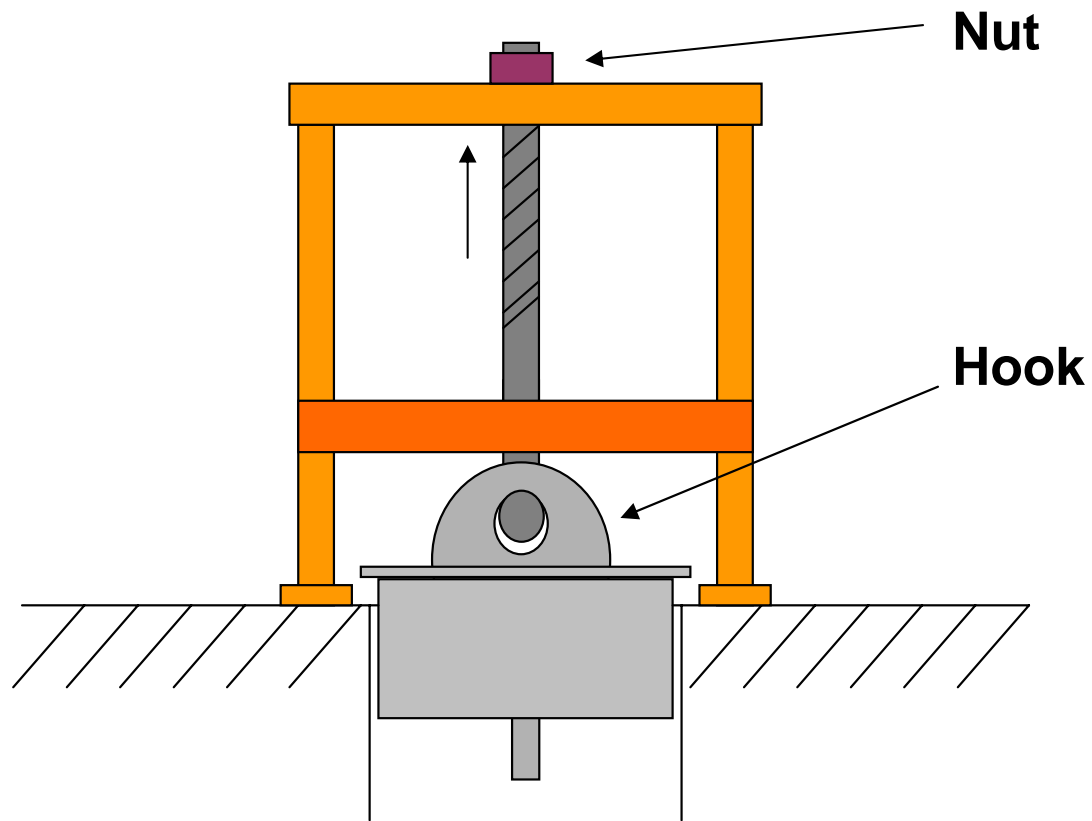


Plugs for Sealing Reserved Duct

Blank Plug with Denso Tape



Custom Design Tool for Easy Removal of Installed Plug



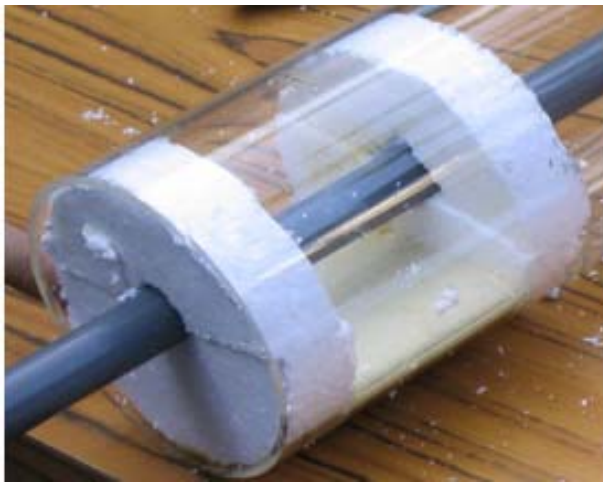
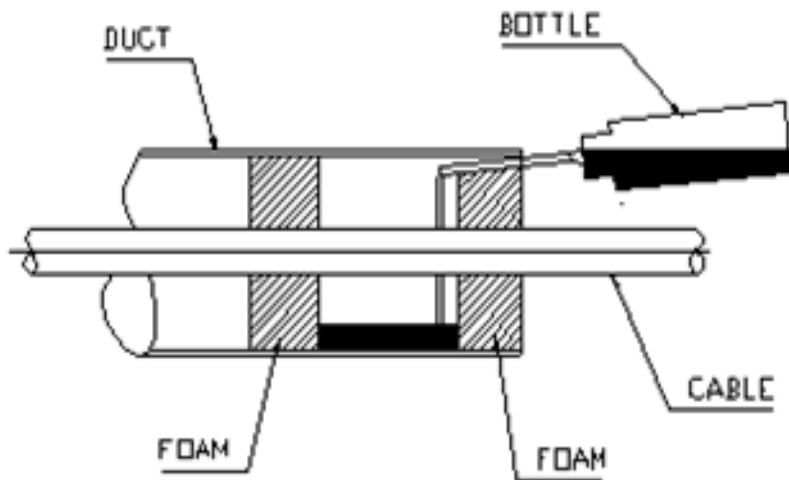
Custom Design Removal Tool

Speedy Removal of Installed Plug



Sealing of Ducts Occupied by Cables

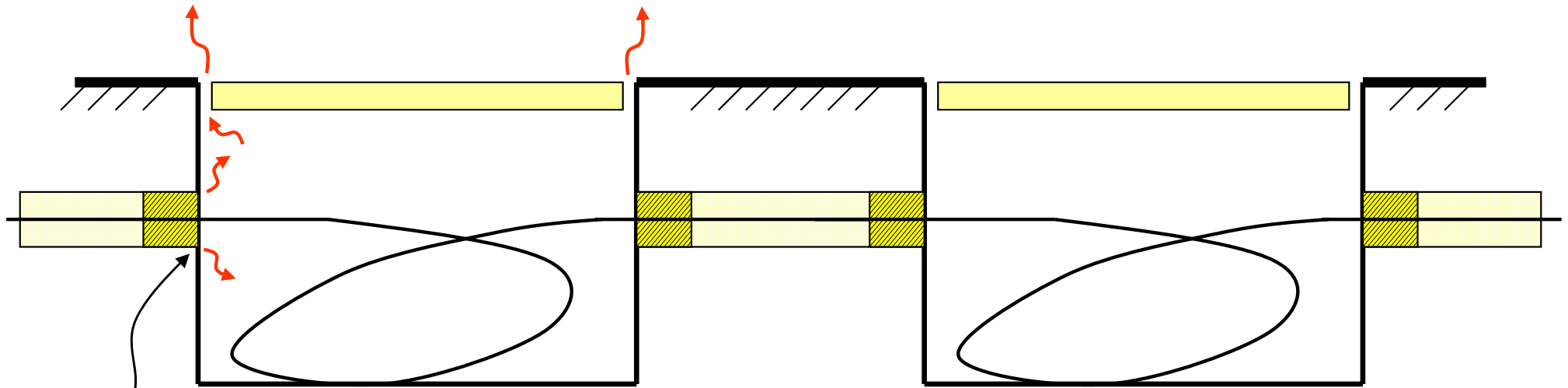
2 Part Resin (Resin Pack 7A)



Speedy Removal of Expanded Foam Seal

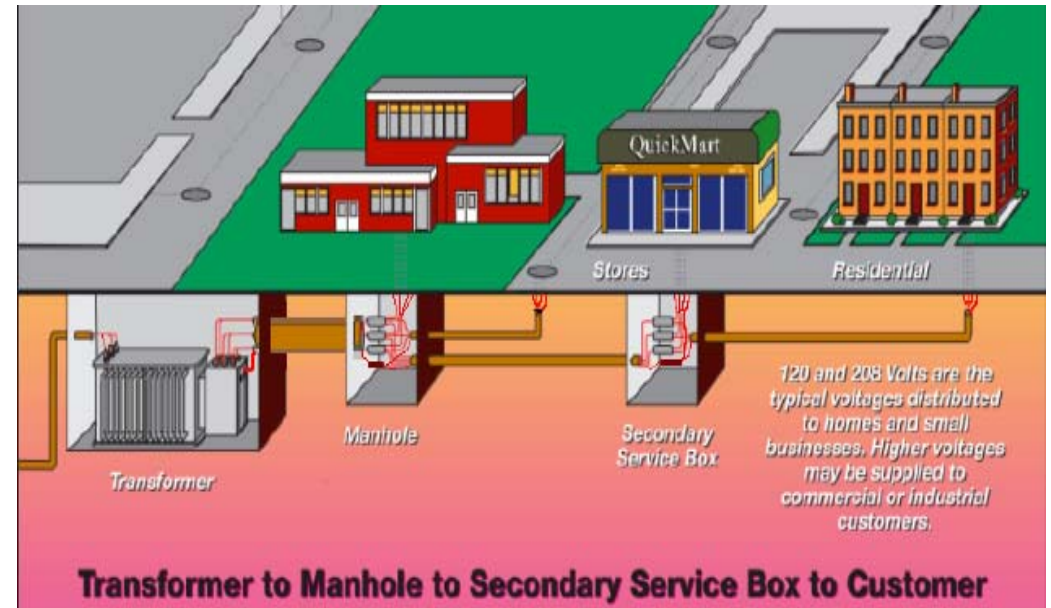


Double Safety



Even if one seal slightly deteriorates,
it will not enter the next manhole

Sample of Duct Sealing adopted by a company in the U.S. for street manholes



Duct Sealing as the Simplest and Most Cost Effective Solution

- Totally eliminate the accumulation of hazardous gases inside manhole
- Easily applied to existing manholes
- Simple Installation
- Low Cost
- Already a standard for ducts entering building

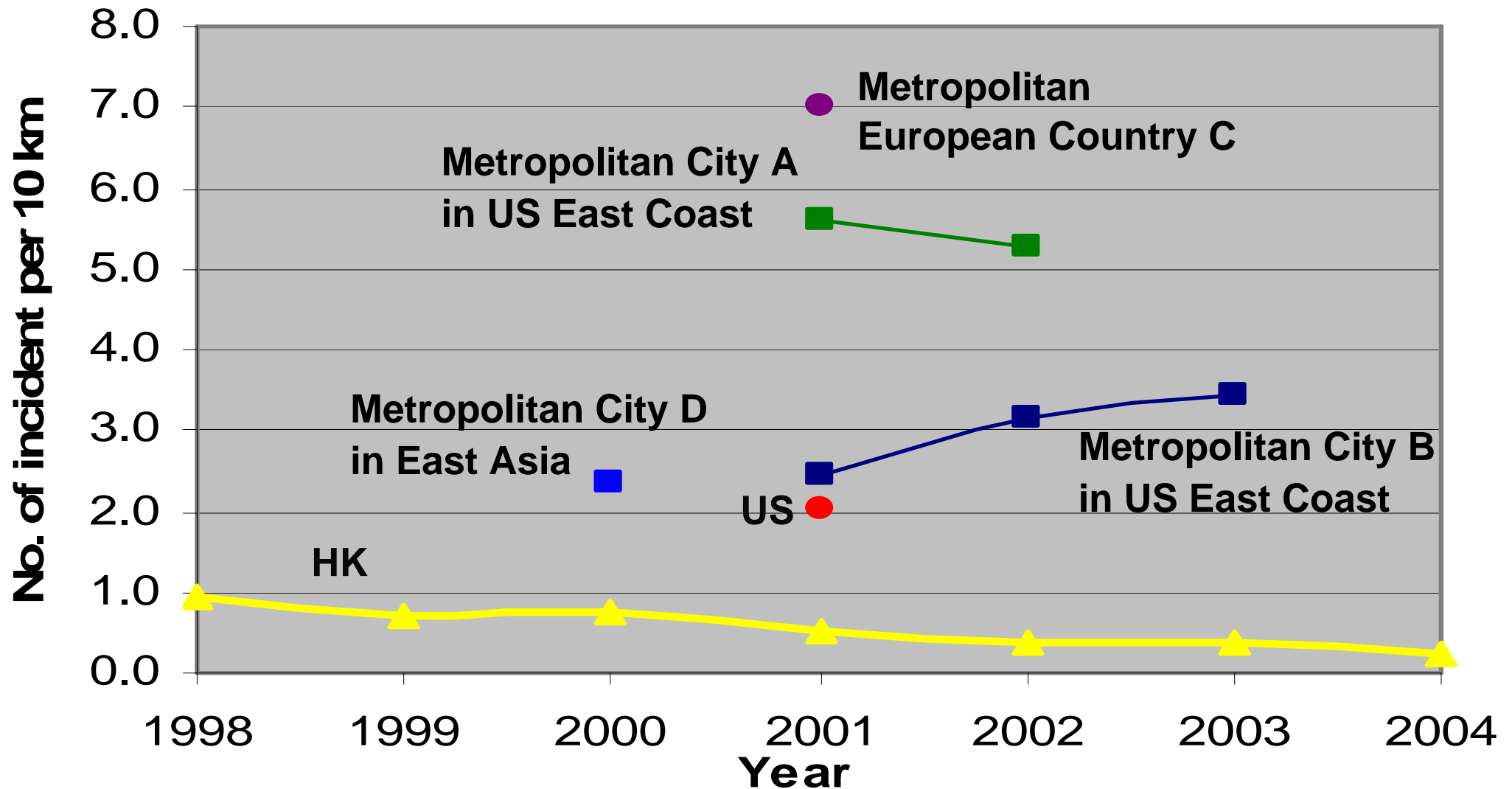
What Have Been Achieved To Date

- Duct Sealing for Building Entry promulgated in Building Rules and Office of Telecommunications Authority (OFTA) Codes.
- Highways' **recommendations** to seal ducts.
- Most telecom companies agreed to seal at least **reserved** ducts of **new** manholes.
- Highways' consultancy study to determine way forward.

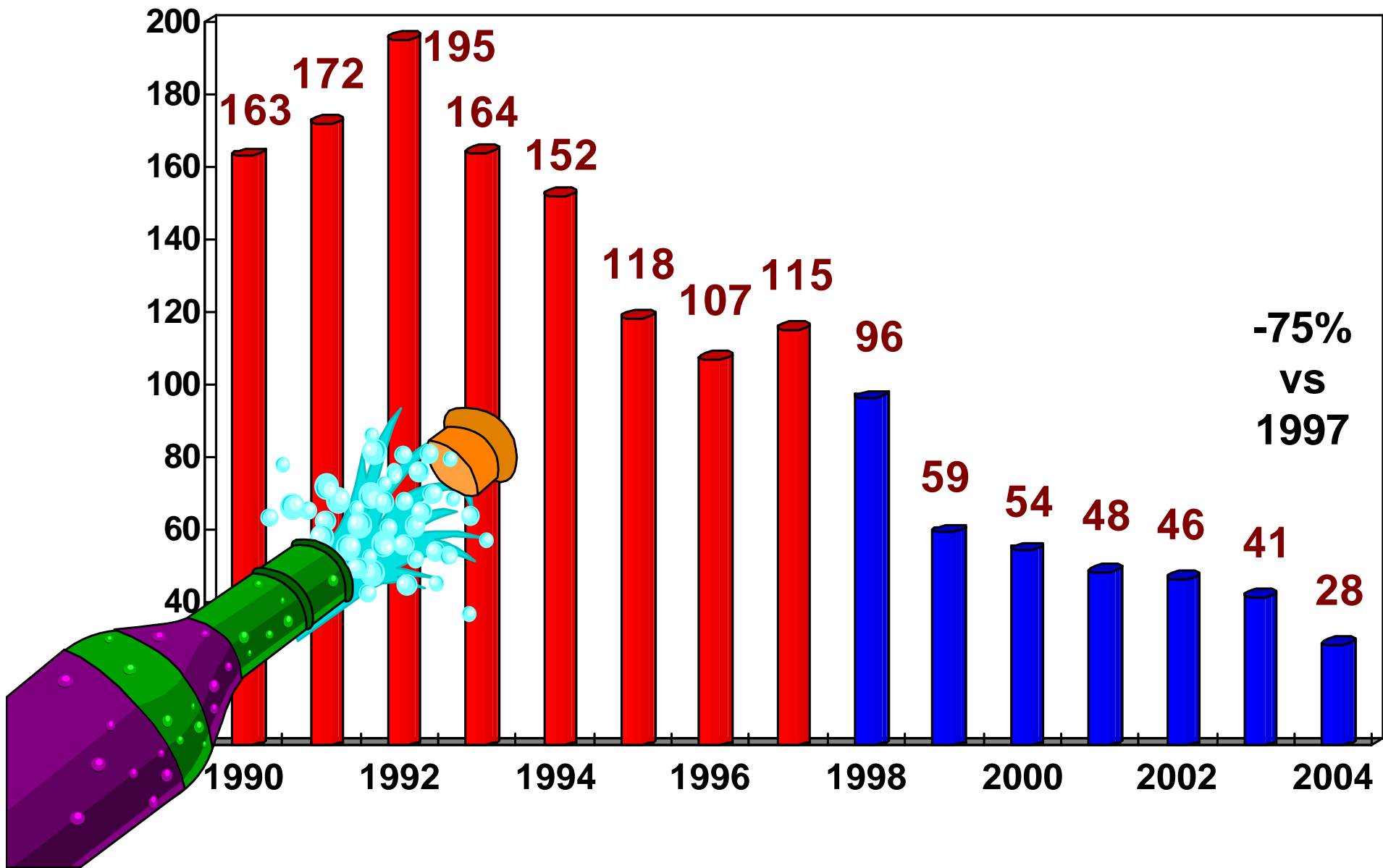
Thank You

Gas Safety – How well are we?

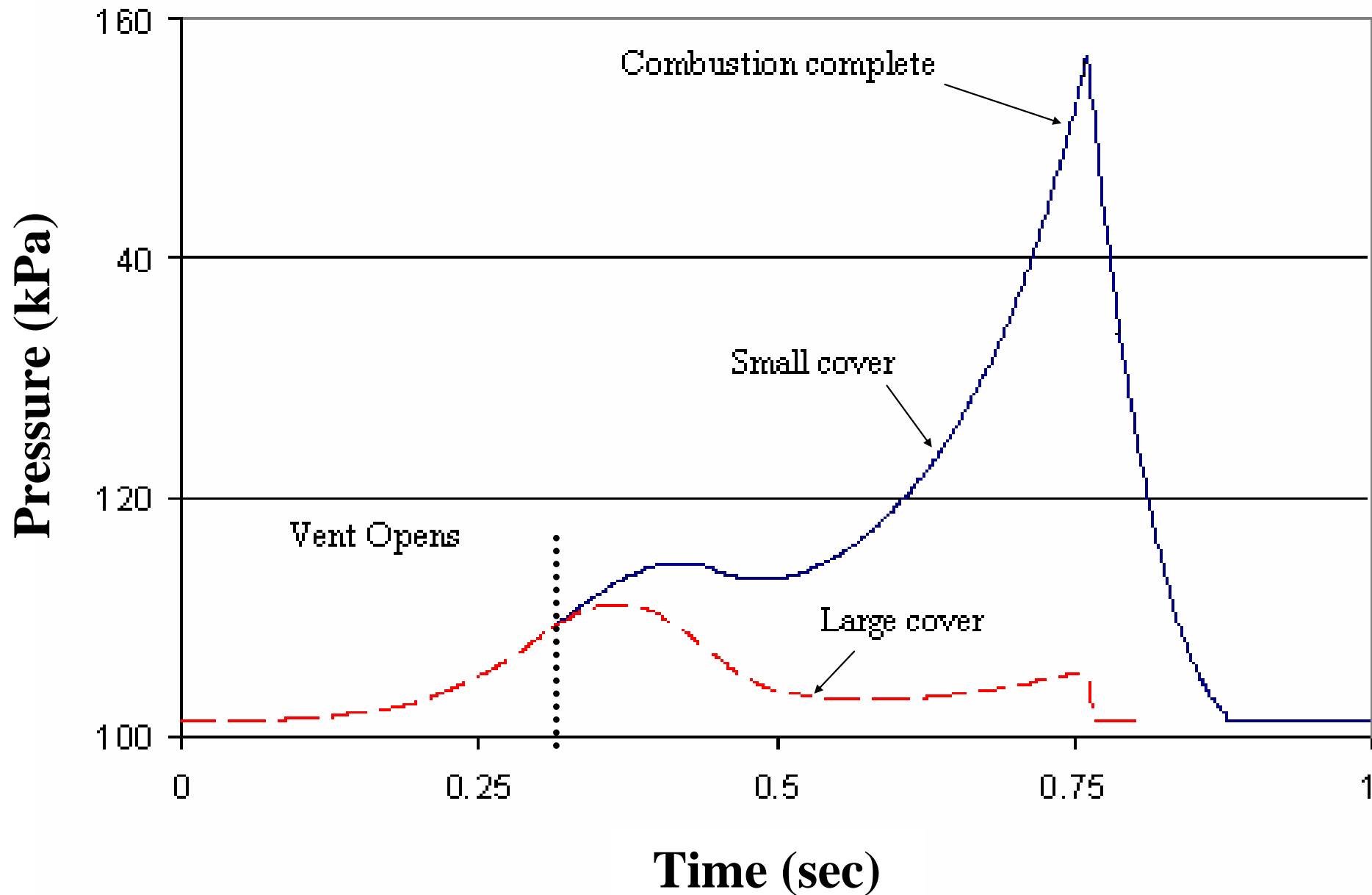
Public Reported Gas Escape (PRE)
per 10km Pipe Length from 1998 to 2004



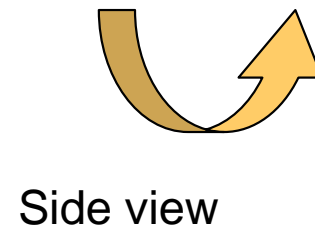
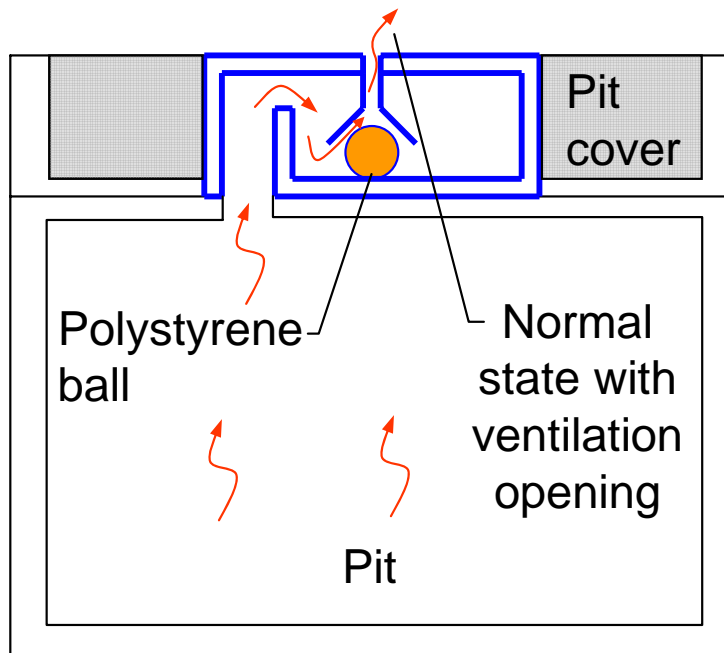
3rd Party Damage to Underground Gas Pipes



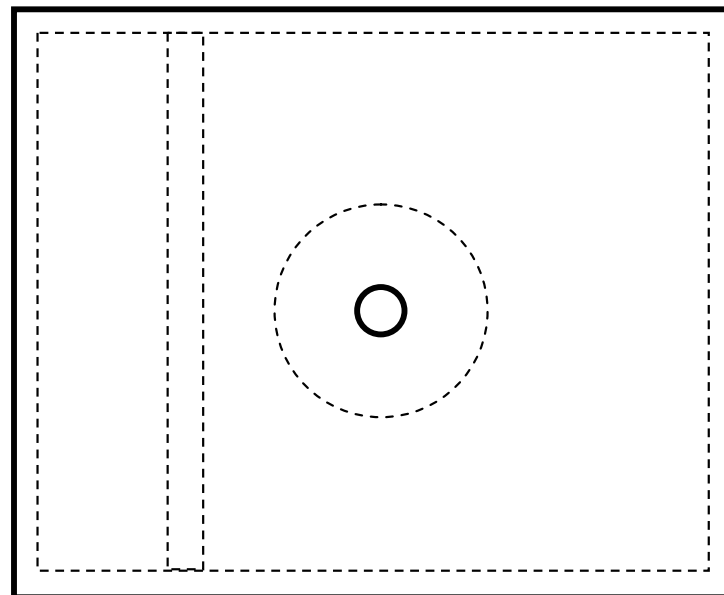
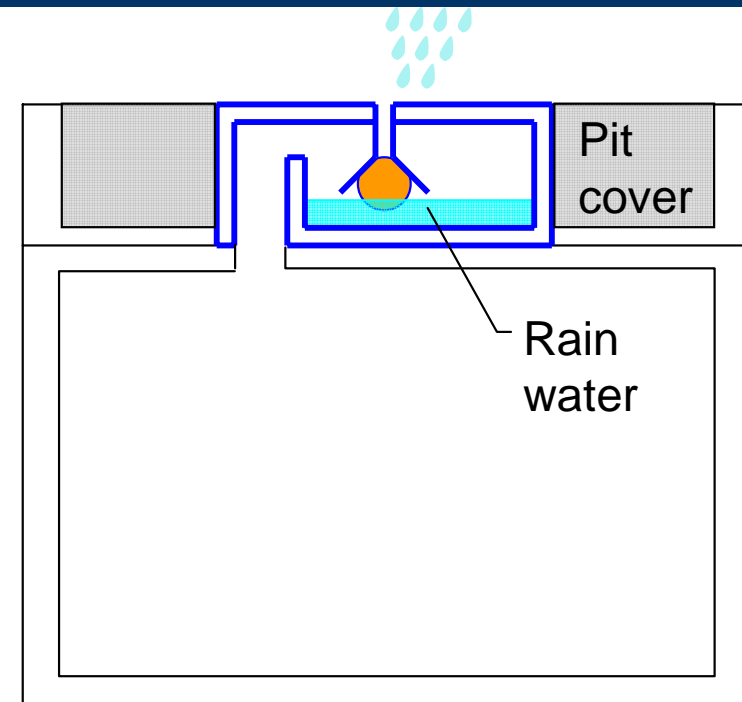
Typical Pressure inside Manhole during Gas Explosion



Venting – Idea to Prevent Ingress of Water



Side view



Top view of Pit Cover

Archimedes' Principle

Upthrust of polystyrene ball blocks the entrance of rain water

Ventilation resumed as long as water evaporated