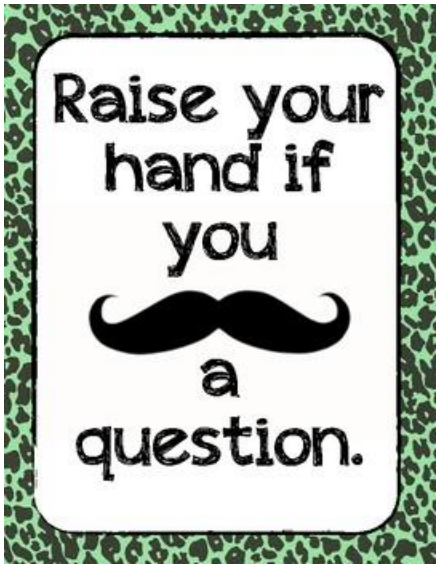
社團法人台灣安全研究與教育學會
Taiwan Safety Council

# 美國CSB事故調查個案研討會

# 安全領導與安全文化事故案例

謝賢書

2015.06. 25



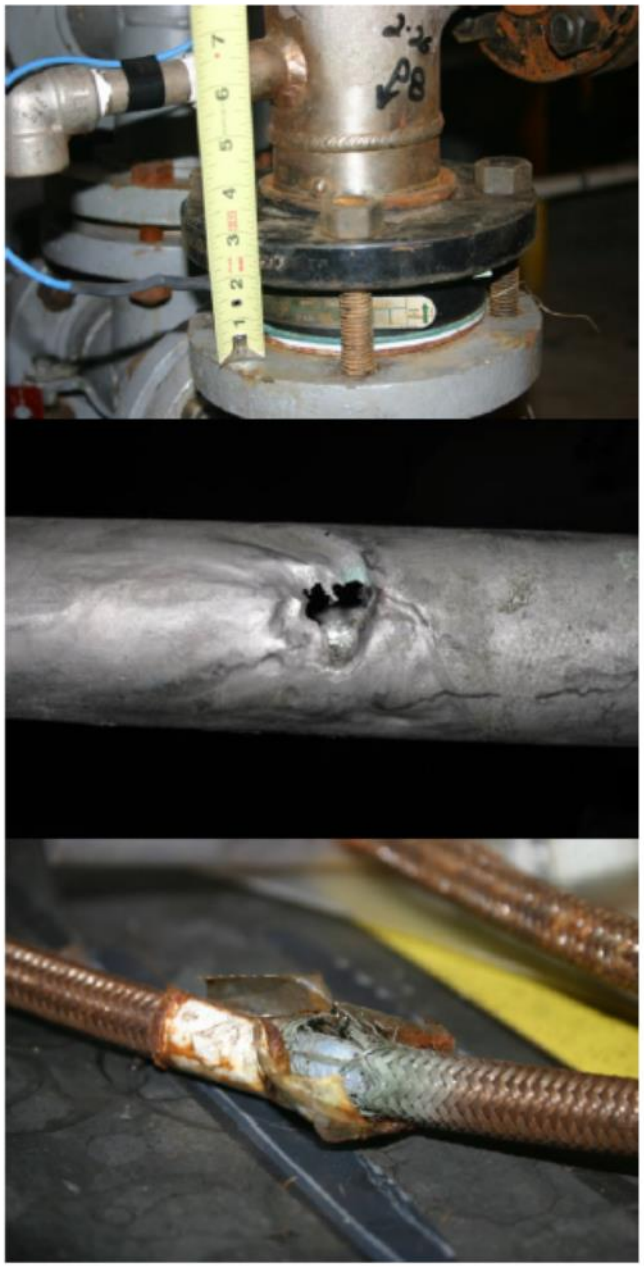

若有任何的想法與問題，
非常歡迎隨時提出

# Belle, West Virginia

- DuPont Corporation (Ellen Kullman, 2008)
  - Belle, West Virginia, chemical manufacturing plant, 2010, 1,22 (1/0)
    - https://www.youtube.com/watch?v=Jtp-p2zxk78
  - Buffalo, 2010,11,9 (1/1)
  - The La Porte factory, Texas, 2014, (4/1)


# Belle, West Virginia, 2010, 1,22

- Methyl Chloride
- Oleum
- Phosgene

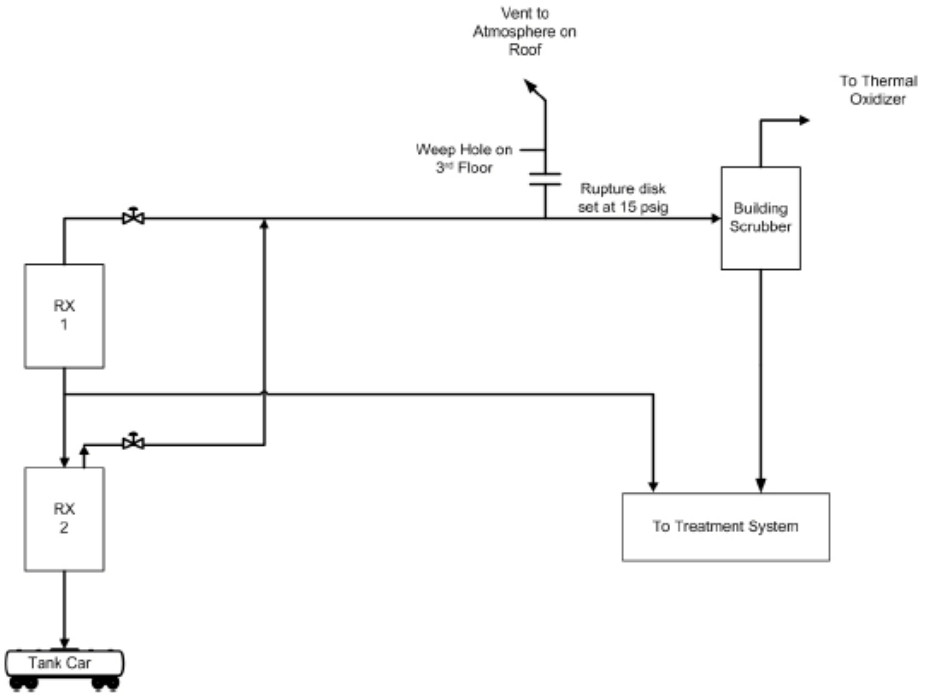


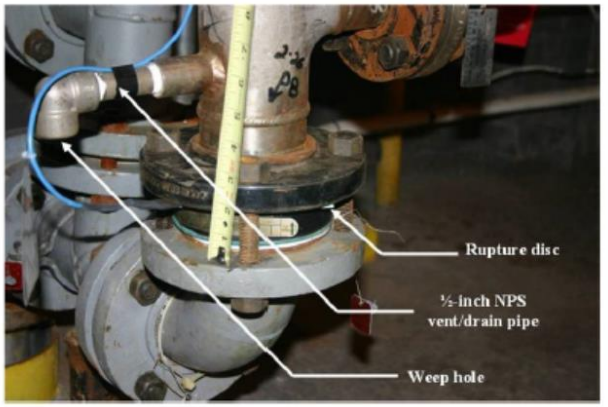
# Methyl Chloride

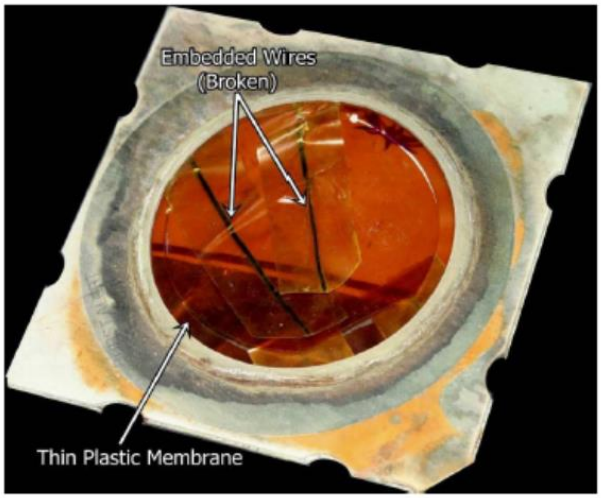
- $CH_3Cl$
- Melting Point: -97 ˚C
- Boiling Point: -23,7 ˚C
- OSHA 8-hr TWA PEL: 100 ppm
- NIOSH Immediately Dangerous To Life or Health (IDLH): 2000ppm
- Oder : not noticeable

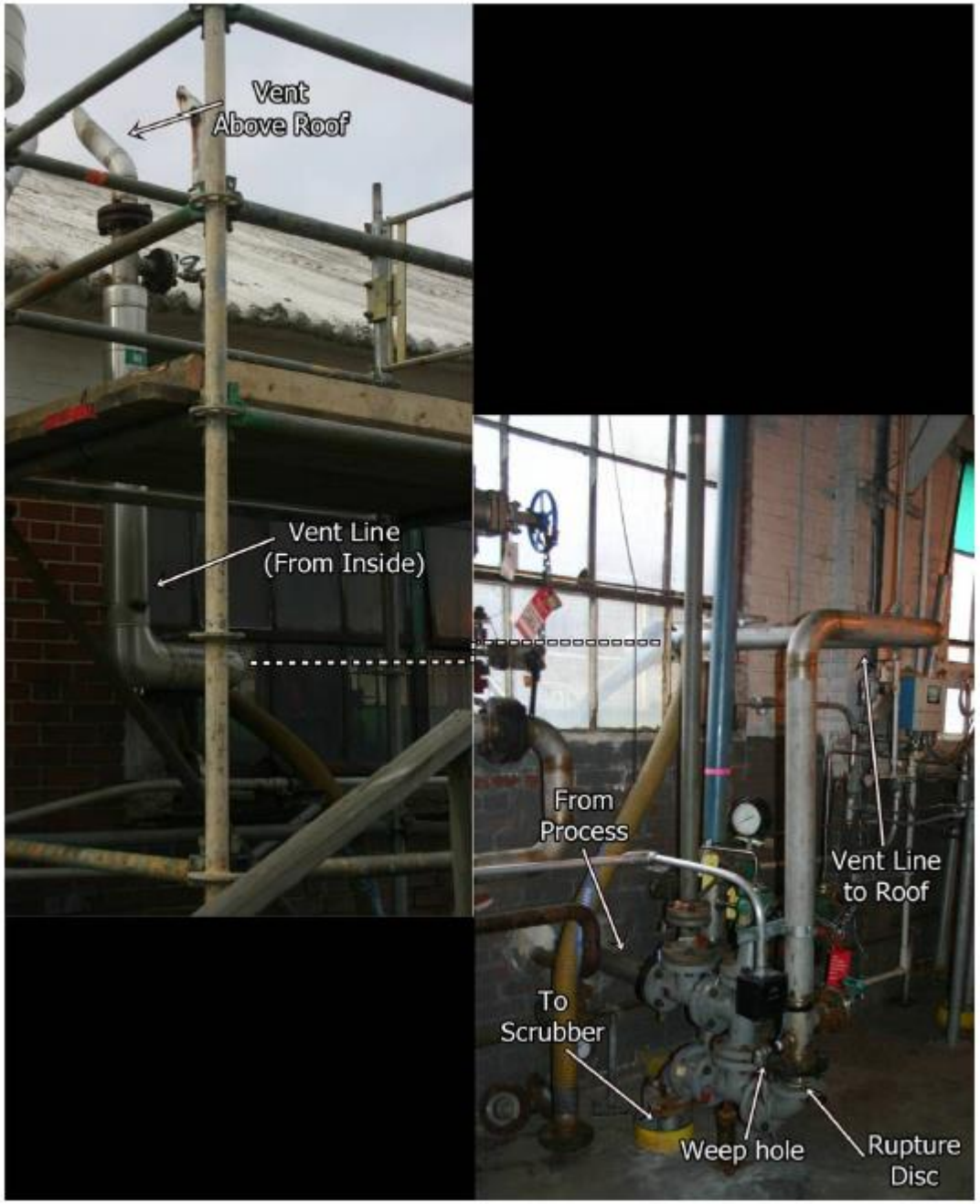
# Methyl Chloride release

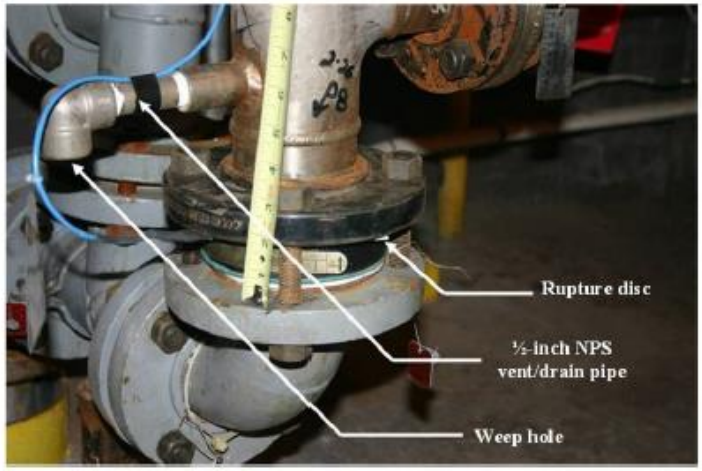
- DCS alarm at 5:02 am, 1/22
- 1/17 – 1/22, 洩漏2000磅

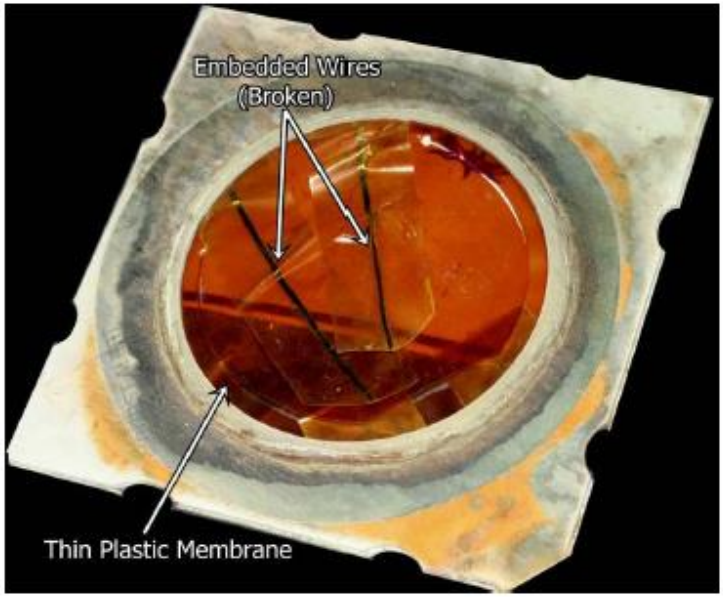


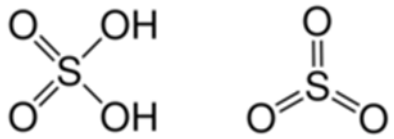

Vent
Above Roof
Vent Line
(From Inside)
From
Process
Vent Line
to Roof
To
Scrubber
Weep hole
Rupture
Disc


Rupture disc
½-inch NPS
vent/drain pipe
Weep hole


Embedded Wires
(Broken)
Thin Plastic Membrane

# Oleum

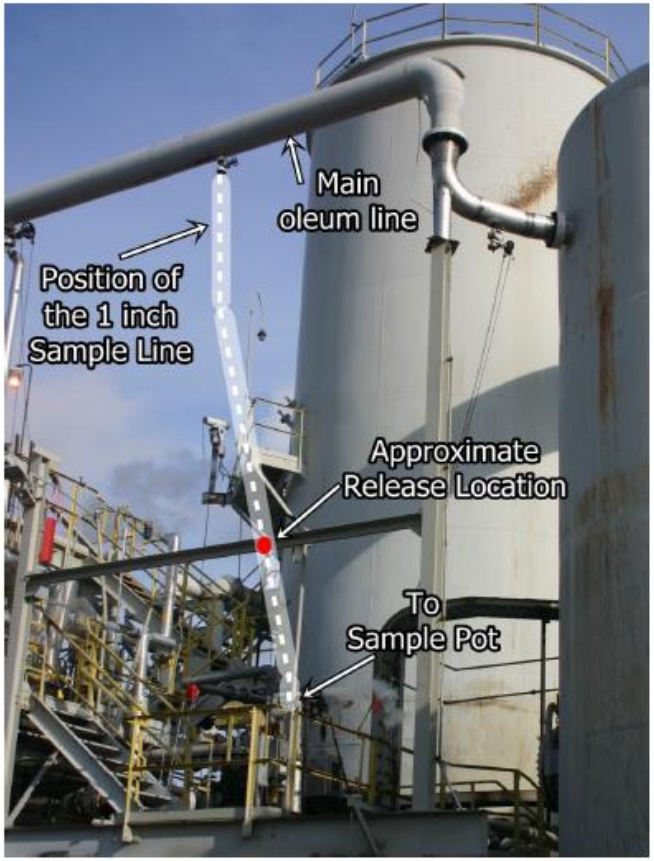
- $H_2S_2O_{7\,(l)} + H_2O_{\,(l)}$ ----> $2H_2SO_{4\,(aq)}$
- 皮膚接觸、吸入、眼睛接觸，會引起灼傷
- OSHA PEL, TWA 8 hours: 1mg/$m^3$
- NIOSH, recommended exposure limit (REL), TWA 10 hours: 1mg/$m^3$



| $\%SO_3$ | bp (℃) |
|---|---|
| 0 | 290 |
| 10 | 175 |
| 20 | 140 |
| 25 | 130 |
| 37 | 100 |

# Oleum release

- 7:40 am, 1/23, 2010 (Saturday)
- 22 pounds of 20% oleum released



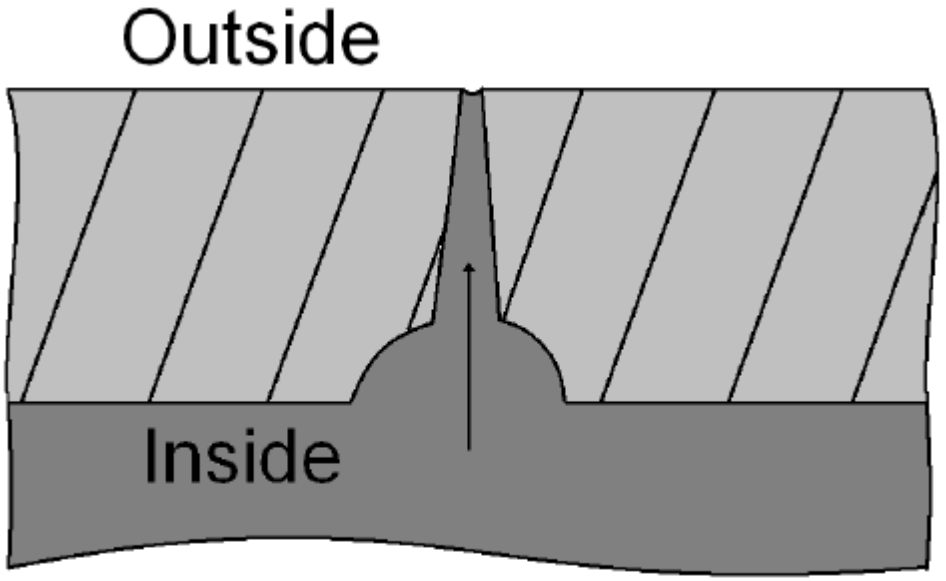
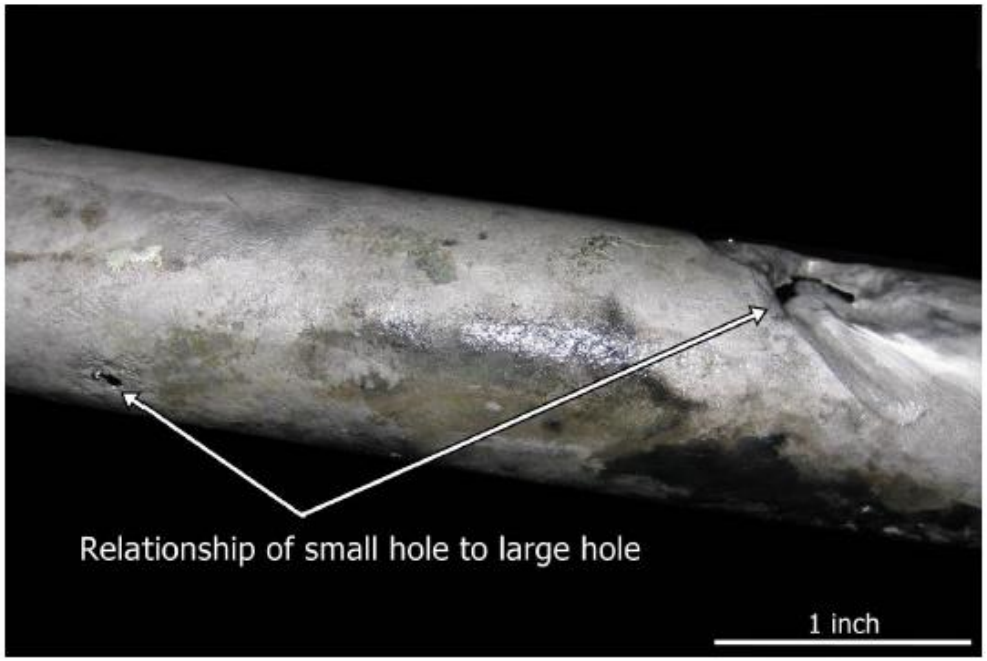



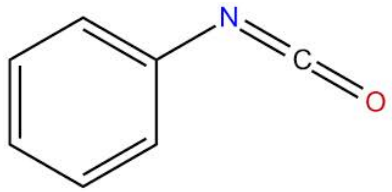

Figure 9. The pitting phenomena in the small initial hole of the oleum sample line wall

# Oleum release



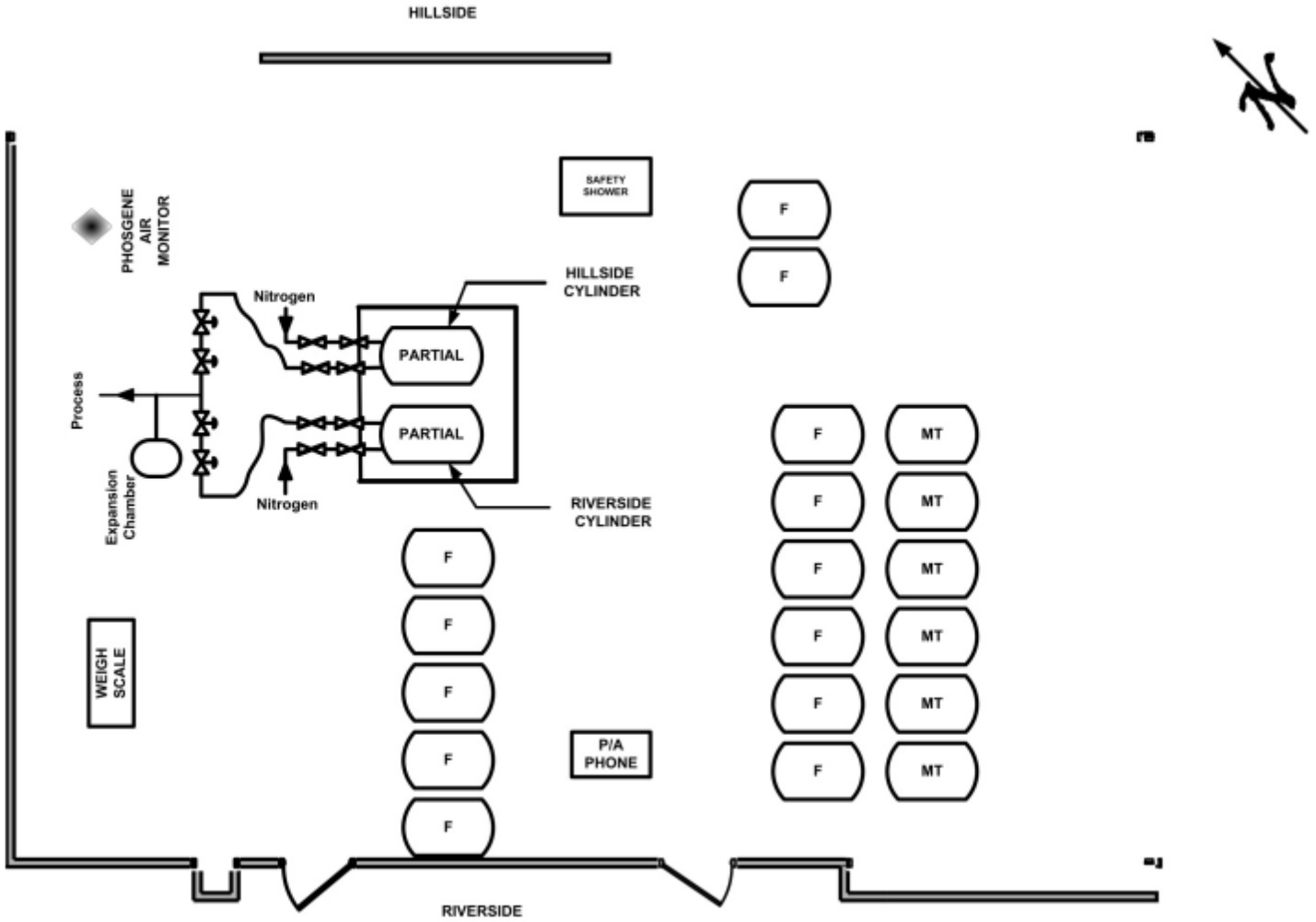

# Phosgene

- $COCl_2$
- Normal BP: 8℃
- OSHA 8-hr TWA PEL: 0.1ppm
- NIOSH Immediately Dangerous To Life or Health (IDLH): 2ppm
- Oder threshold: 0.4-1.0 ppm
- 製造異氰酸酯isocyanate 中間產物

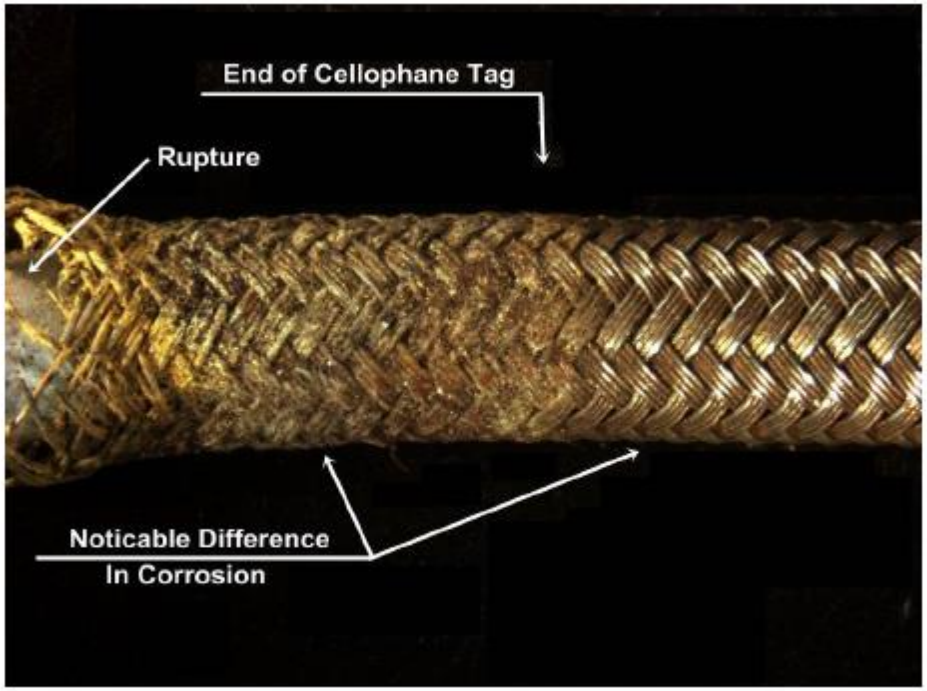


# Phosgene release

https://www.youtube.com/watch?v=Jtp-p2zxk78



# Phosgene release




# Phosgene release

# Phosgene release

| DuPont P3H Standard Hoses for Phosgene Service | | |
|---|---|---|
| **Name** | **Specifications** | |
| | | |
| **H2** | Inner core material: | Monel® 400, corrugated |
| | Reinforcement material: | Monel® 400 overbraid |
| | End fitting material: | Monel® 400 SCH. 80 |
| | Core/fitting connection method: | Welded, full penetration |
| | | |
| **H7** | Inner core material: | Hastelloy® C276, corrugated |
| | Reinforcement material: | Monel® 400 or Hastelloy® C276 overbraid |
| | End fitting material: | Hastelloy® C276 stub ends |
| | Core/fitting connection method: | Welded, full penetration |
| | | |
| **H9** | Inner core material: | Teflon®[44] PTFE, helical, corrugated, taped or extruded construction, unpigmented or conductive |
| | Reinforcement material: | PVDF (Kynar®) double overbraid |
| | End fitting material: | Monel® 400, Hastelloy® C276, or Teflon® encapsulated SS |
| | Core/fitting connection method: | Crimped (or swaged) |

Table 3. Flexible hoses for phosgene service as listed in the DuPont P3H Standard: Flexible Chemical Hose for Highly Toxic Services

| Hose Change-out Frequency | | |
|---|---|---|
| Month/Year | Phosgene Hoses | Phosgene Used |
| Jul-05 | Changed | Phosgene Used |
| Aug-05 | Changed | |
| Sep-05 | Changed | |
| Oct-05 | Changed | |
| Nov-05 | Changed | |
| Dec-05 | | |
| Jan-06 | | Phosgene Used |
| Feb-06 | | Phosgene Used |
| Mar-06 | Changed | Phosgene Used |
| Apr-06 | | Phosgene Used |
| May-06 | | Phosgene Used |
| Jun-06 | Changed | Phosgene Used |
| Jul-06 | Changed | Phosgene Used |
| Aug-06 | | |
| Sep-06 | | |
| Oct-06 | Changed | |
| Nov-06 | Changed | |
| Dec-06 | | |
| Jan-07 | | Phosgene Used |
| Feb-07 | | Phosgene Used |
| Mar-07 | Changed | Phosgene Used |
| Apr-07 | | Phosgene Used |
| May-07 | Changed | Phosgene Used |
| Jun-07 | | Phosgene Used |
| Jul-07 | | Phosgene Used |
| Aug-07 | | |
| Sep-07 | Changed | |
| Oct-07 | | |
| Nov-07 | | |
| Dec-07 | | |
| Jan-08 | | Phosgene Used |
| Feb-08 | | Phosgene Used |
| Mar-08 | | Phosgene Used |
| Apr-08 | Changed | Phosgene Used |
| May-08 | Changed | Phosgene Used |
| Jun-08 | | Phosgene Used |
| Jul-08 | Changed | Phosgene Used |
| Aug-08 | Changed | |
| Sep-08 | | |
| Oct-08 | | |
| Nov-08 | | |
| Dec-08 | | |
| Jan-09 | Changed | Phosgene Used |
| Feb-09 | | Phosgene Used |
| Mar-09 | | Phosgene Used |
| Apr-09 | | Phosgene Used |
| May-09 | | Phosgene Used |
| Jun-09 | Changed | Phosgene Used |
| Jul-09 | | Phosgene Used |
| Aug-09 | | |
| Sep-09 | | |
| Oct-09 | | |
| Nov-09 | | |
| Dec-09 | | |
| Jan-10 | | Phosgene Used |

# Phosgene release

- 請描述事故發生的因素，包括
  - 直接原因 (immediate causes)
  - 促成因素 (contributing causes)
  - 根本原因 (root causes)

- 請描述想進一步調查的事項

# 安全管理系統

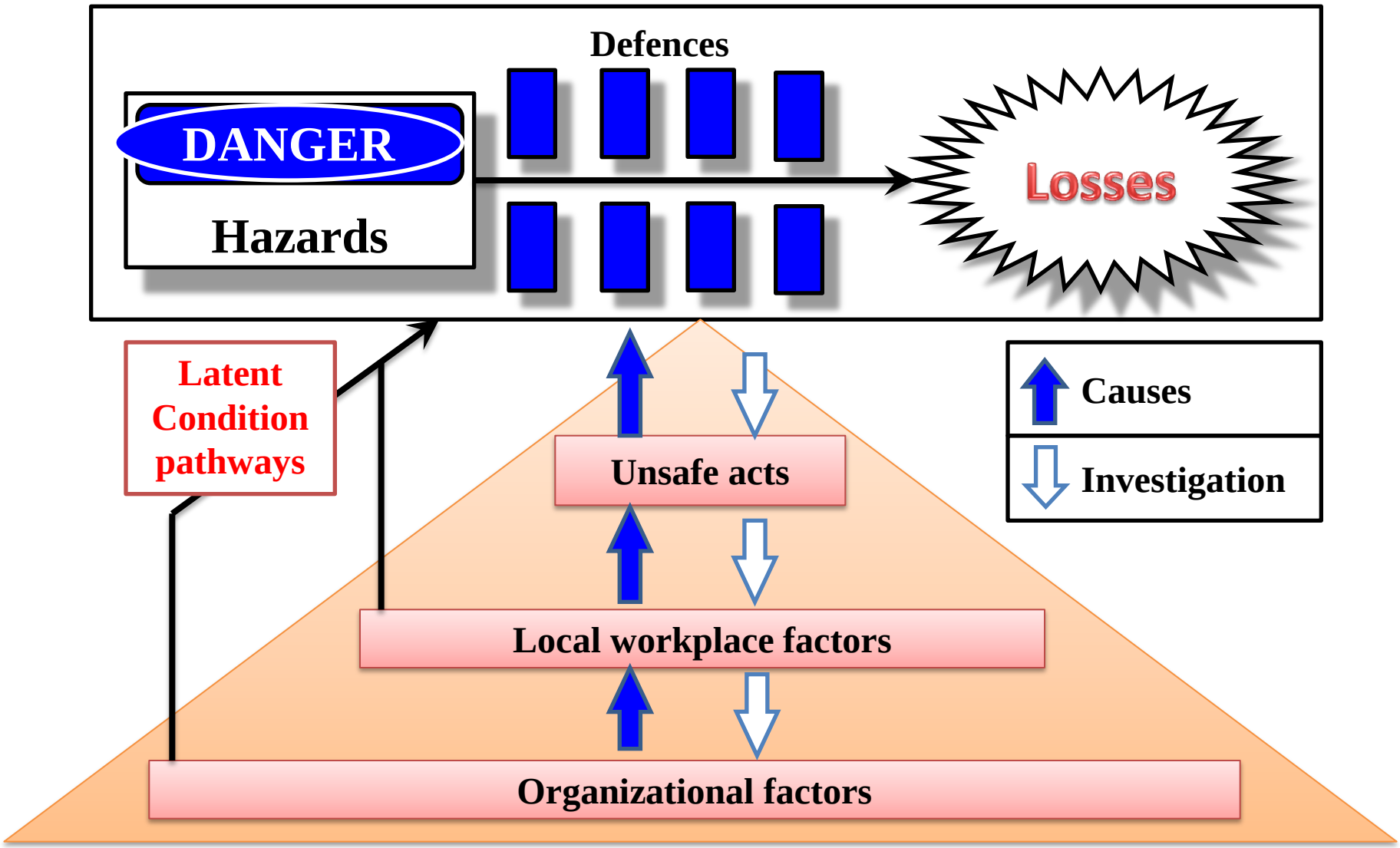
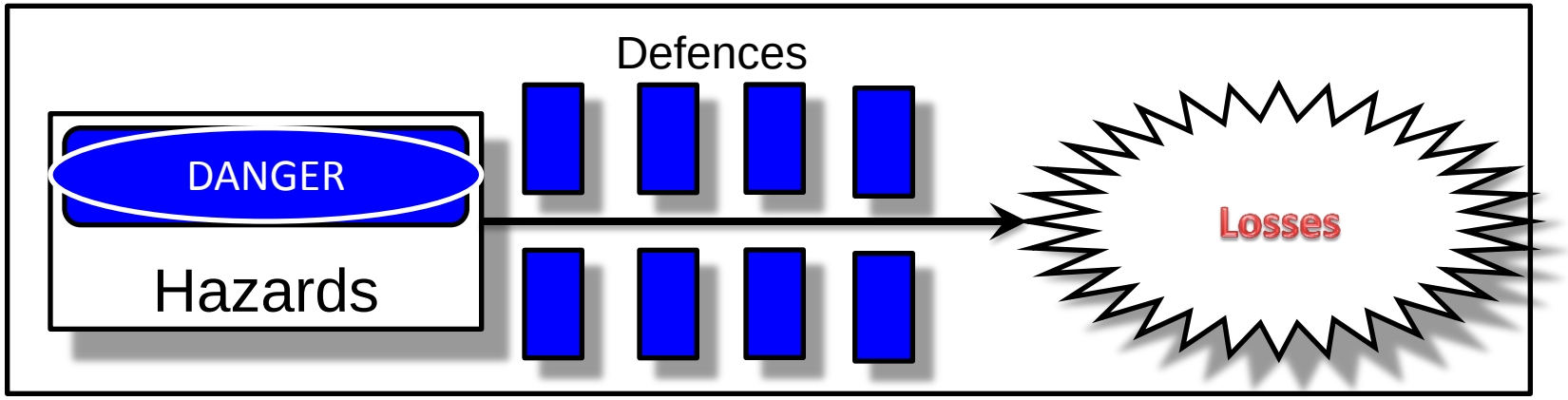
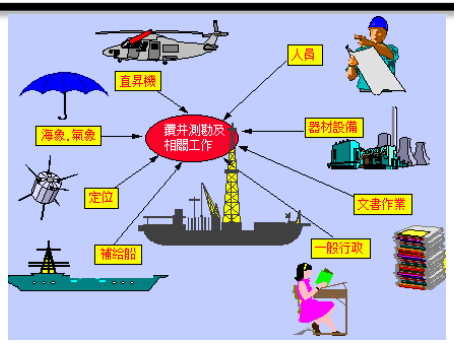



**Fig.3. Reason's accident causation model(Source, Reason, 1997, p.17).**

# 安全管理系統




- 人資
- 採購
- 財會
- 稽核
- 品質安衛
- 資訊
- 企劃
- 法務

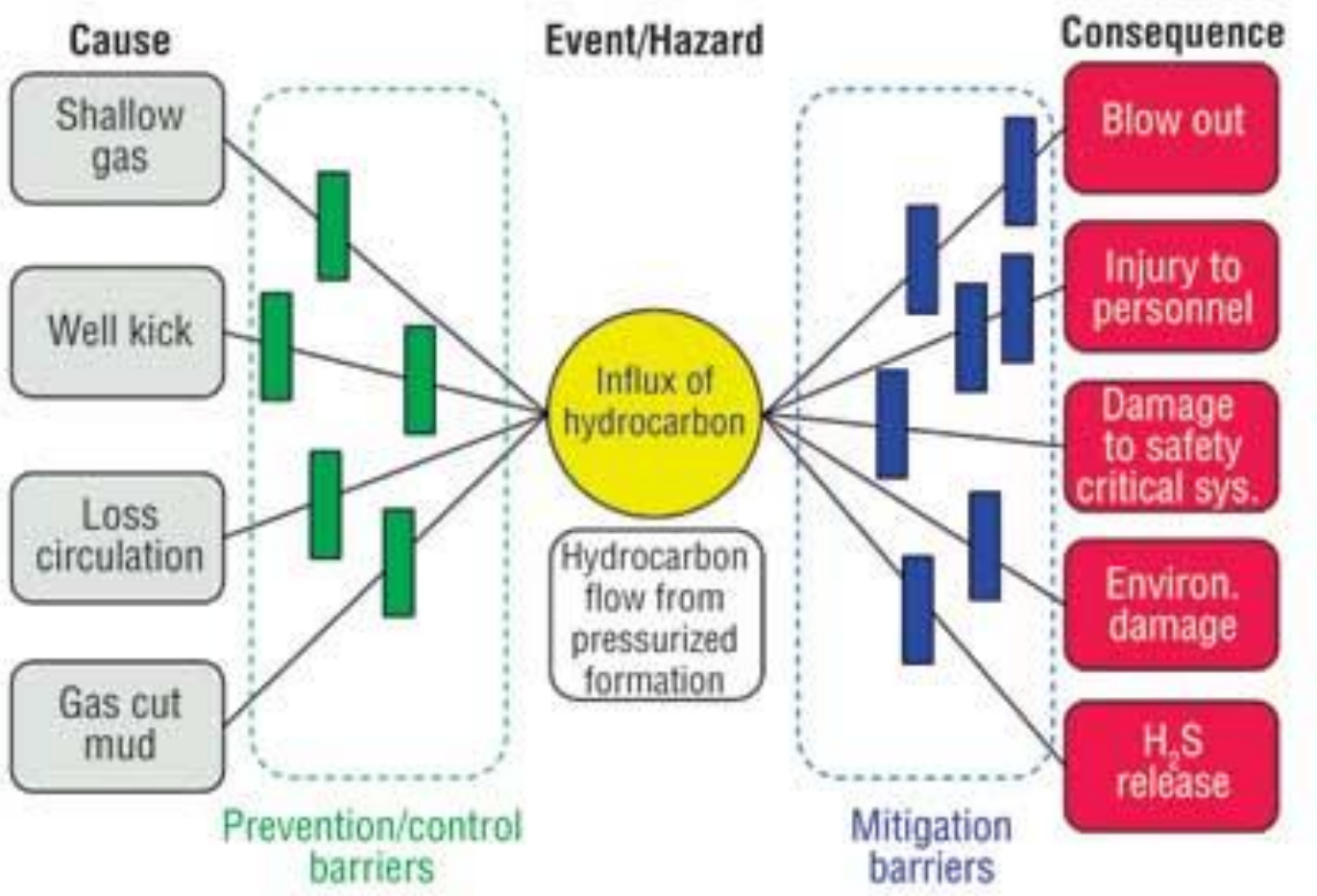



- 設計
- 建造
- 操作
- 維護

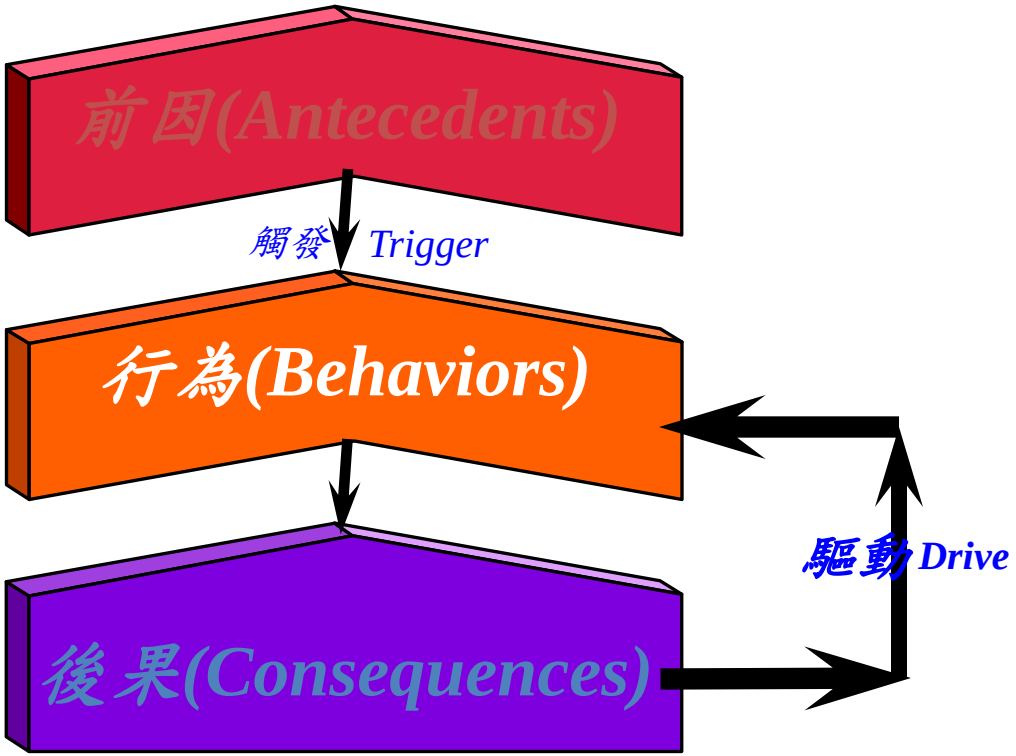
Reason's accident causation model (1997).

# 蝴蝶結分析方法 BOW-Tie Model

- To mitigate drilling hazards and control the well

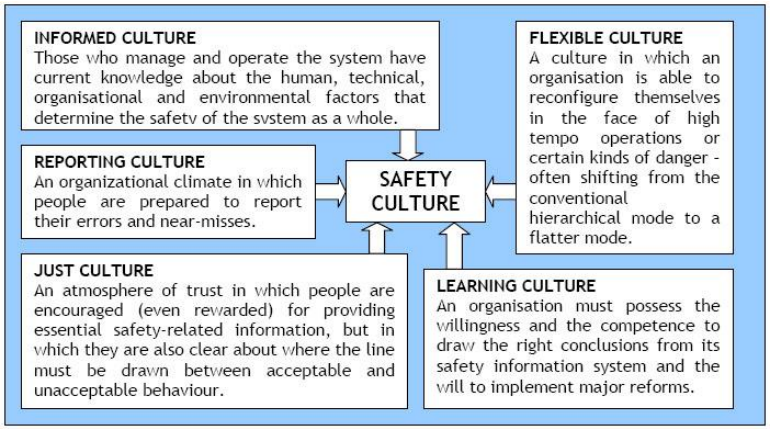


# 行為ABC分析


前因(Antecedents)
觸發 Trigger
行為(Behaviors)
驅動 Drive
後果(Consequences)

# 「重視工作安全」的企業文化特徵

- 學習的文化
- 創新的文化
- 分享的文化
- 紀律與授權的文化
- 容許（非故意）犯錯的文化
- 重視團隊合作的文化
- 追根究柢的文化
- 誠實的文化
- 信任的文化



# 製程安全管理Process Safety Management

| | |
|---|---|
| 全員參與 | employee involvement |
| 製程資訊 | process safety information |
| 製程危害分析 | process hazard analysis |
| 操作程序 | operating procedure |
| 訓練 | training |
| 承攬管理 | contractor |
| 開機前檢查 | pre-start safety review |
| 機械完整性 | mechanical integrity |
| 動火作業 | hot work permit |
| 變更管理 | management of change |
| 事故調查 | incident investigation |
| 緊急應變管理 | emergency planning and response |
| 稽核 | compliance audit |
| 業務機密 | trade secret |

# CCPS 邁向製程安全的20項

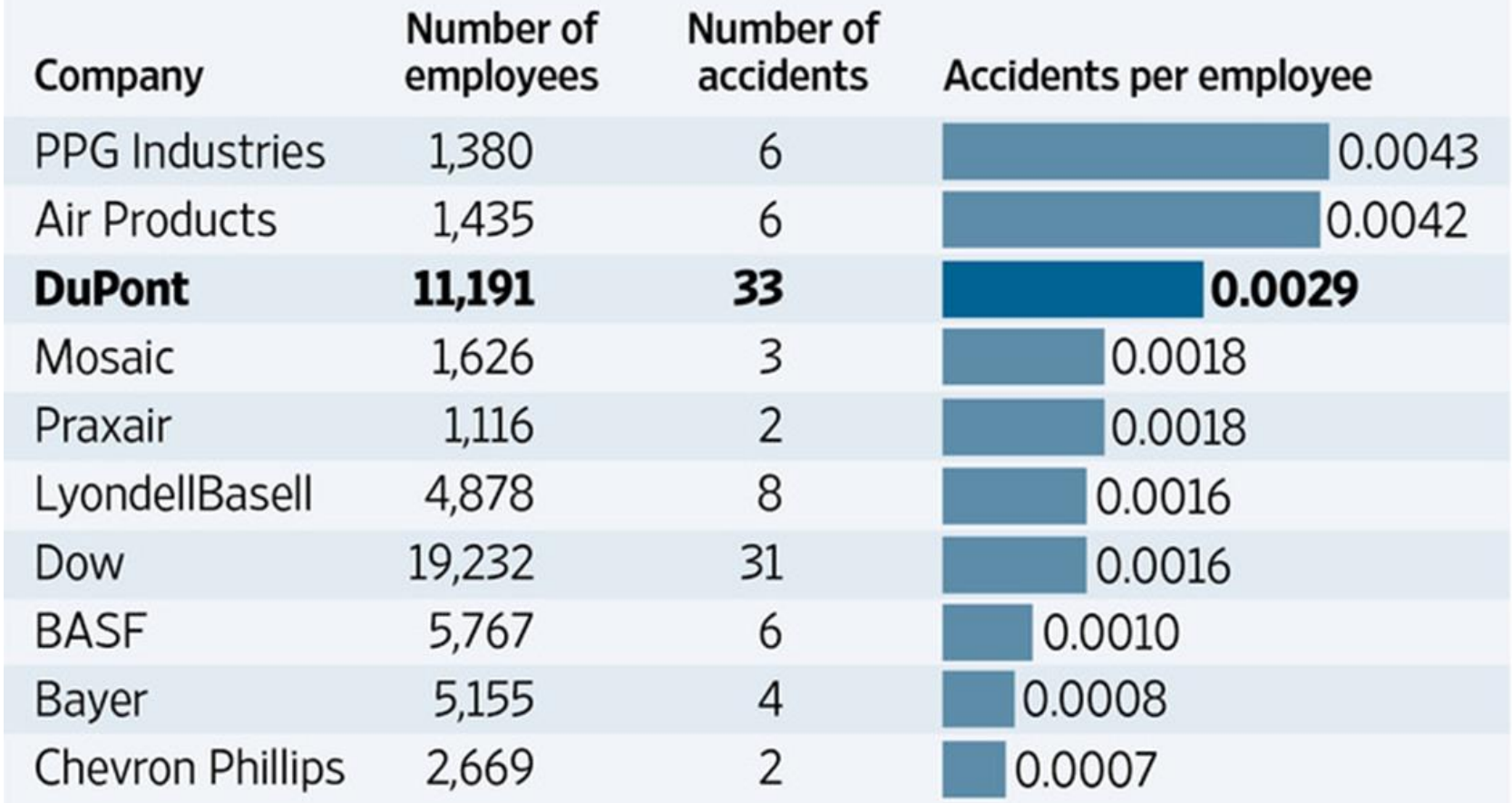
| | |
|---|---|
| **Process Safety Culture** | 製程安全文化 |
| **Compliance with Standards** | 遵守規範標準 |
| **Process Safety Competency** | 製程安全能力 |
| **Workforce Involvement** | 員工參與 |
| **Stakeholder Outreach** | 利害相關者的延繫 |
| **Process Knowledge Management** | 製程知識管理 |
| **Hazard Identification and Risk Analysis** | 危害辨識與風險分析 |
| **Operating Procedures** | 操作程序 |
| **Safe Work Practices** | 安全作業 |
| **Asset Integrity and Reliability** | 資產完整性與可靠度 |

# CCPS 邁向製程安全的20項

| | |
|---|---|
| **Contractor Management** | 承攬管理 |
| **Training and Performance Assurance** | 訓練與確保績效 |
| **Management of Change** | 變更管理 |
| **Operational Readiness** | 完備的操作環境與團隊 |
| **Conduct of Operations** | 操作紀律 |
| **Emergency Management** | 緊急應變管理 |
| **Incident Investigation** | 意外事件調查 |
| **Measurement and Metrics** | 績效量測與指標 |
| **Auditing** | 稽核 |
| **Management Review and Continuous Improvement** | 管理審查與持續改善 |

# Keeping Tabs

How DuPont compares with other chemical companies in the number of accidents reported to the U.S. Environmental Protection Agency over a five-year span:



| Company | Number of employees | Number of accidents | Accidents per employee |
|---|---|---|---|
| PPG Industries | 1,380 | 6 | 0.0043 |
| Air Products | 1,435 | 6 | 0.0042 |
| **DuPont** | **11,191** | **33** | **0.0029** |
| Mosaic | 1,626 | 3 | 0.0018 |
| Praxair | 1,116 | 2 | 0.0018 |
| LyondellBasell | 4,878 | 8 | 0.0016 |
| Dow | 19,232 | 31 | 0.0016 |
| BASF | 5,767 | 6 | 0.0010 |
| Bayer | 5,155 | 4 | 0.0008 |
| Chevron Phillips | 2,669 | 2 | 0.0007 |

Source: Wall Street Journal analysis of EPA data collected by the Center for Effective Government in May 2013.

The Wall Street Journal

# Q & A