CASE STUDY PRESENTATION ON PIPER ALPHA AND SAN JUANICO INCIDENT

Conference on Chemical (Industrial) Disaster Management (CIDM)

C. Abhiram , GM (HSE), IOCL

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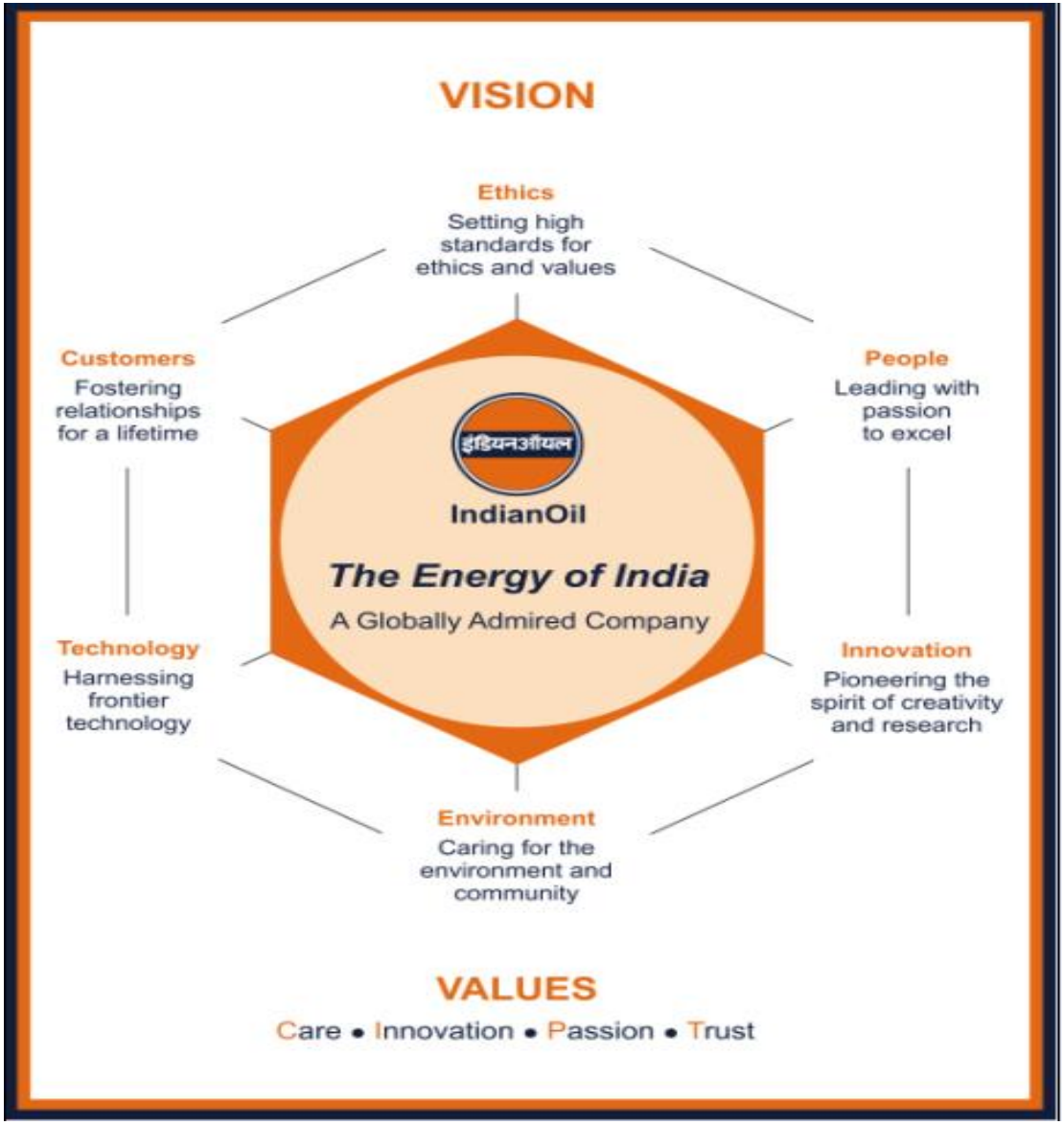
Presentation Agenda

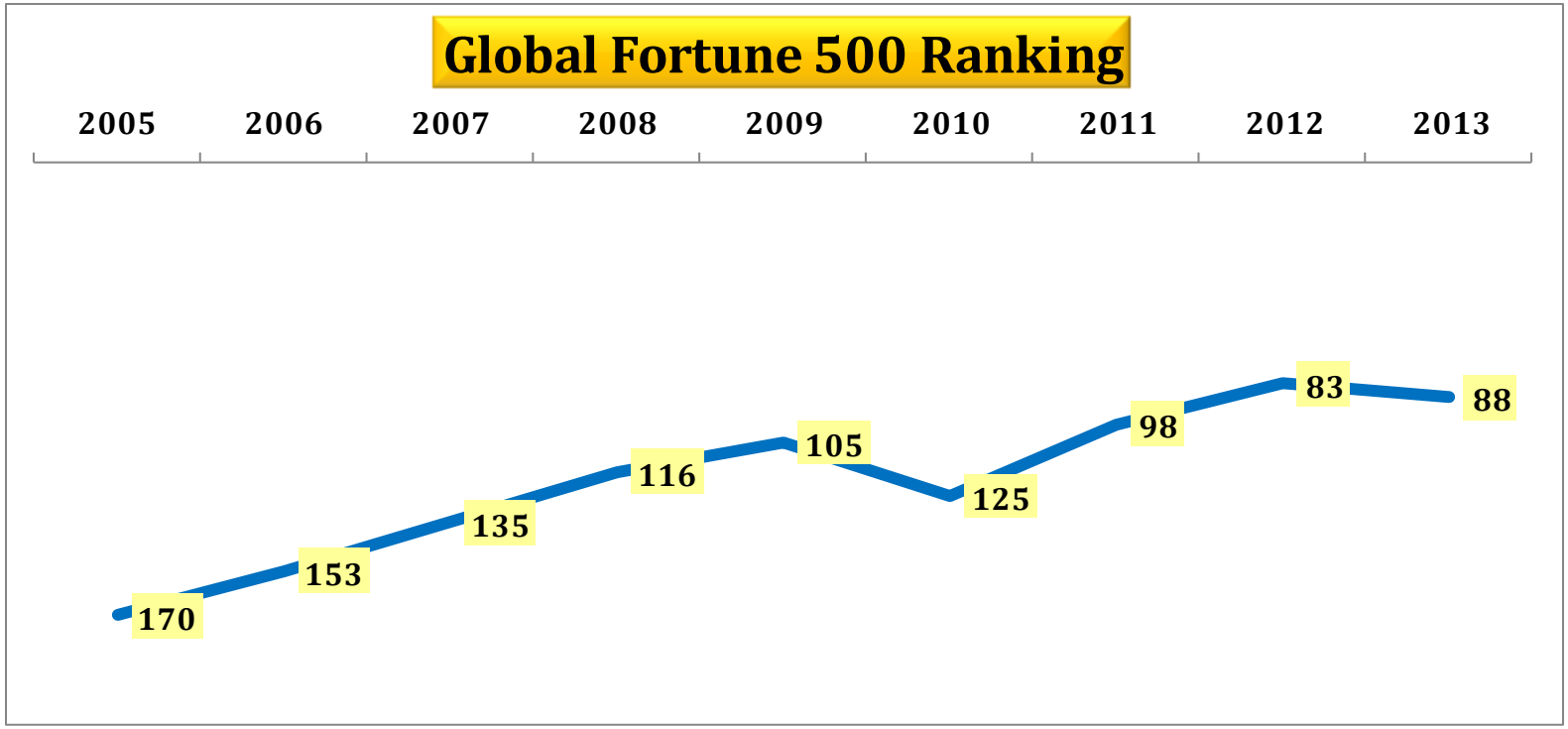
- Brief about Indian Oil
- Petroleum Industry Hazards
- Causes of Accidents
- Piper Alpha
- San Juanico Mexico
- Way Forward

Brief About Indian Oil

IndianOil –Vision



Global Fortune Ranking



Highest-ranked Indian Company in Global Fortune 500 ranking

Business Space

As on 1.4.2014

Group Refining

- 10 out of 22 refineries in the country
- 65.7 MMTPA capacity (31%)

Marketing

- More than 41,000 Touch Points (52%)
- 81.8 million LPG customers

Pipelines

- Over 11200 Km length
- 80.5 MMTPA capacity

R&D

- Lube formulations
- In-house technologies
- Patents (292)

Petrochemicals

- Operate world scale Naphtha Cracker unit
- Major player in petrochemicals in India (19.4% market share)
- Export to 46 countries

Exploration & Production

- Domestic:13 Blocks NELP(11),CBM(2)
- Over Seas :11 blocks Libya (3), Iran (1), Yemen (2), Nigeria (1), Gabon (1), & Venezuela (1), USA (1), Canada (1)

Gas

- Co-promoter in M/s PLL
- LNG at Doorstep
- CGD
- Gas infrastructure (Storage / Transportation)

Renewable

- •Biofuel : Captive plantation
- •Wind : 63 MW capacity
- •Nuclear : Equity partnership
- •Solar: Grid-connected 5 MW PV solar power plant, Solarization of ROs (1266)

Overseas Presence

Indian Oil Mauritius Ltd.

(100%)

- Aviation, terminaling and retail
- Leader in aviation (53.2%)
- 13.5% retail infrastructure share
- 25.23% market share in POL sales

Lanka IOC Ltd.

(75.1%)

- Storage, terminaling and retail business
- 15.6 % retail infrastructure share
- Over 15% market share in MS
- 1/3rd share in Ceylon Petroleum Storage Terminals Ltd
- Listed in the Colombo Stock Exchange

IOC Middle East FZE

(100%)

- Marketing of *SERVO* lube & petroleum products in Middle East, Africa and CIS countries.
- Exports finished lubes to Oman, Yemen, Bahrain, UAE and Nepal.

Health Safety & Environment (HSE)

- Monitor compliance of statutory occupational health requirements
- Carry out Nutritional Evaluation Audit (Health & Hygiene of Canteens / Kitchens

- Organize & conduct specialized safety programmes
- Conduct random safety audits of installations

- Environment Management Audit
- Monitor compliance of Environment Protection rules & regulations

RESPONSIBLE CARE

All the refineries are Euro III / IV compliant ,ISO-9001,ISO-14001. OHSAS:18001 certified & ISO-14064 verified.

Sustainable Development

Water Footprint Reduction

- Waste water treatment and reuse
- 352 Rain Water Harvesting Systems installed
- Water conservation measures

Waste Management

- Oily sludge, Catalysts & Organic / Canteen Waste
  - Disposed off responsibly

Clean Development Mechanism Projects

Alternate Energy based Power Projects

- Grid Connected
  - Wind
  - Solar
  - Nuclear
- Off-Grid

Energy Efficiency

- Reduction in specific energy (MBN) of refineries (55.8)
- Flare gas recovery
- Energy Efficiency in buildings

Tree Plantation

- Making major events carbon neutral by planting trees

Petroleum Industry Hazards

Why Safety

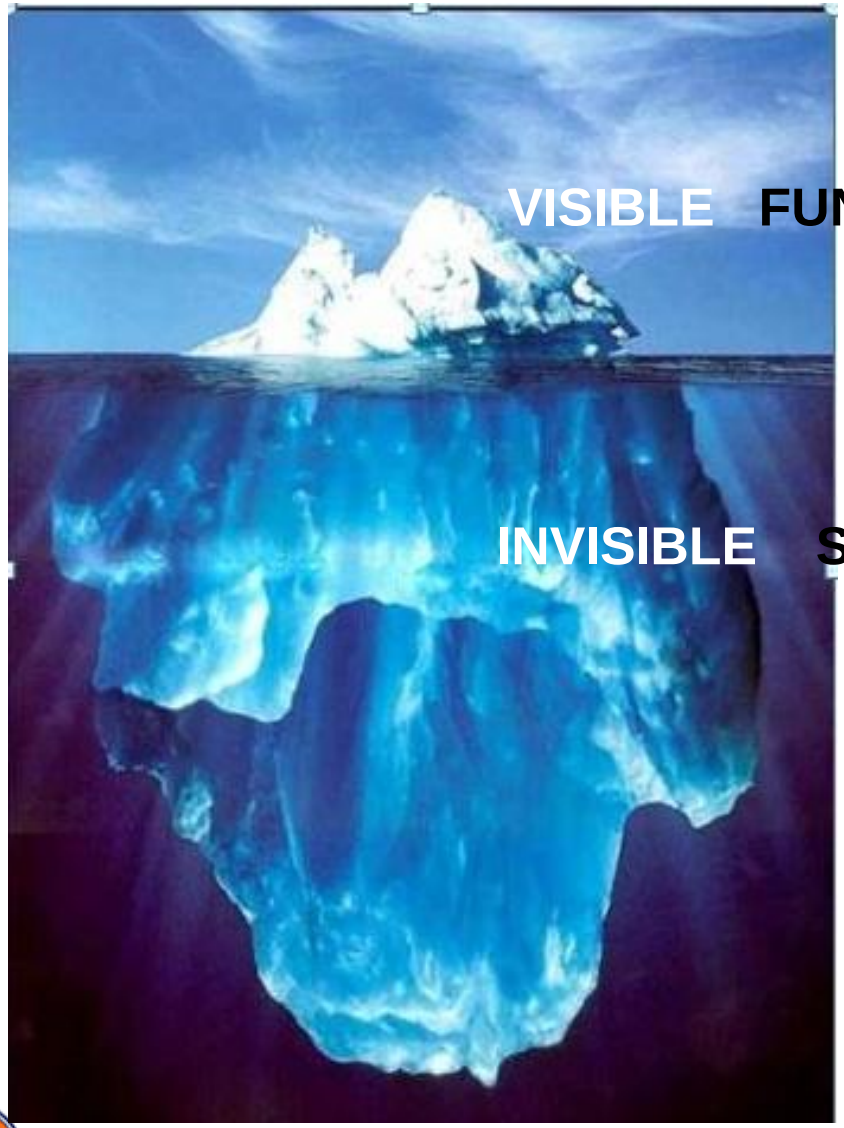
- To protect human life.
- To protect company property.
- To enhance corporate image.
- To efficiently run the business.
- To enhance productivity.
- To build up morale & team spirit.
- Low morale
- Criminal liability
- Civil liability
- Moral responsibility
- Poor output performance
- Staff turnover
- To protect surrounding environment/ community
- Higher insurance

Special Risks Associated with Petroleum Industry

- **Highly flammable material**
- **High Temperature/Pressure**
- **Modern Technologies using complex systems.**
- **Corrosivity/Reactivity**
- **Self Ignition on Leakage from System**
- **Uncontrolled Process Reactions**
- **Loss of Containment/Accidental Releases**

Causes of Accidents

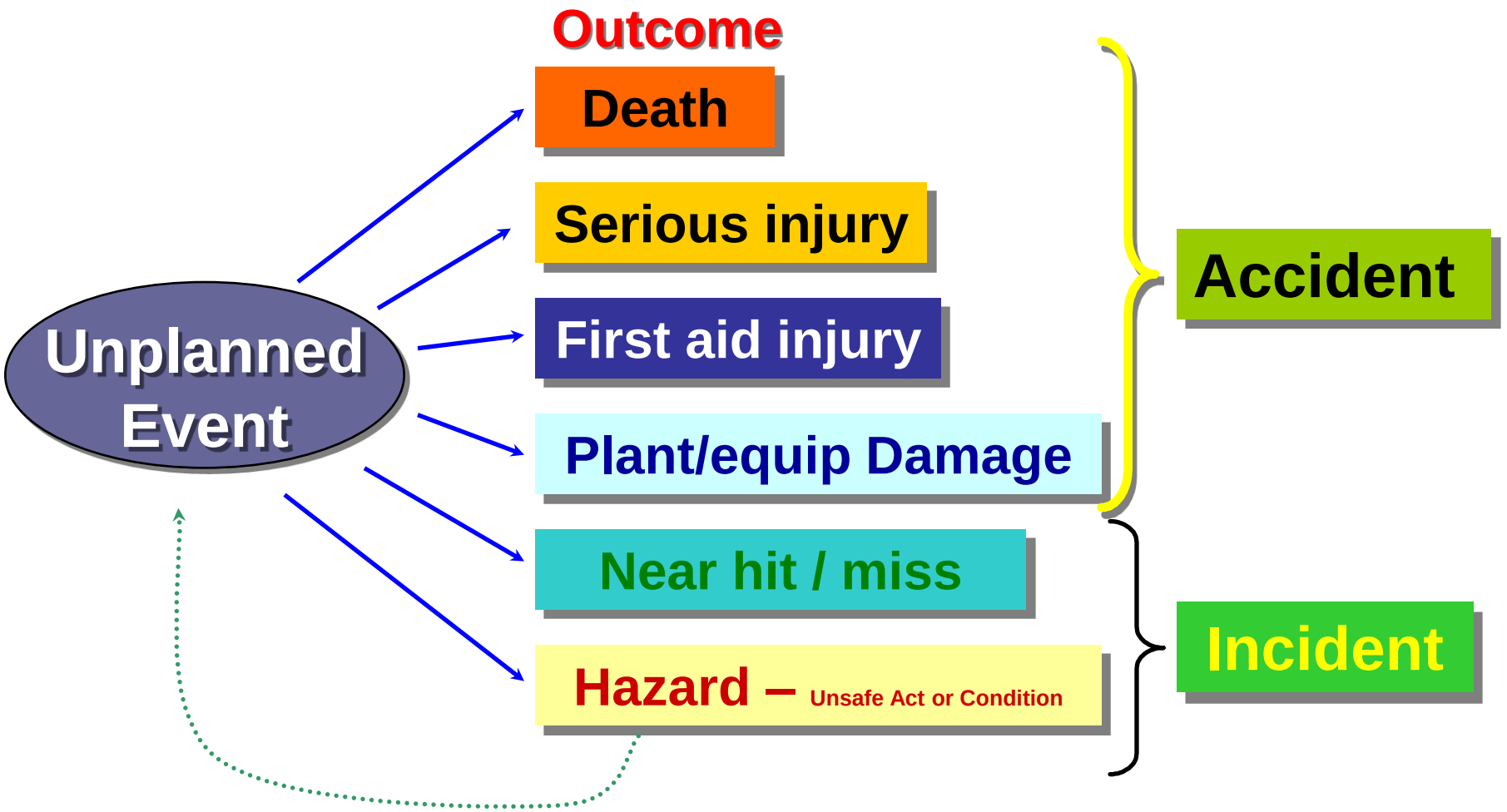
SAFETY CULTURE



Equipment, Procedures, Processes, Shutdowns, Maintenance

Attitudes, Values, Competencies, Skill, Training & Behaviour of individuals

Unplanned Events and Outcomes



Causes of Accidents

- **Causes of accidents are:-**
  - **Unsafe Acts**
  - **Unsafe Conditions**

Unsafe Acts

- **Standing on top step of step ladders**
- **Removing guards from machines**
- **Leaving materials on floor of a corridor**
- **Blocking a doorway or escape route**
- **Not wearing correct PPE**
- **Putting chemicals in unmarked containers**
- **Using machines or tools without training**
- **Not following the Standard Operating Procedures**

Unsafe Conditions

- **Unstable or dangerous working platform**
- **Dangerous machinery**
- **Materials and trip hazards on floor**
- **Blocked access routes and exits**
- **Excessive noise levels, or dust in air etc.**
- **Overcrowding**
- **External factors such as weather etc.**

Causes of Unsafe Acts and/or Conditions

- **Lack of:-**
  - **Experience**
  - **Training**
- **Poor Supervision**
- **Laziness**
- **Distractions**
- **Pressures:-**
  - **Peers**
  - **Management**
- **Cost:-**
  - **Time**
  - **Equipment**
- **Personal Pressures:-**
  - **Your team playing tonight?**
  - **Problems at home**
- **Human Errors**
  - **Forgetfulness**

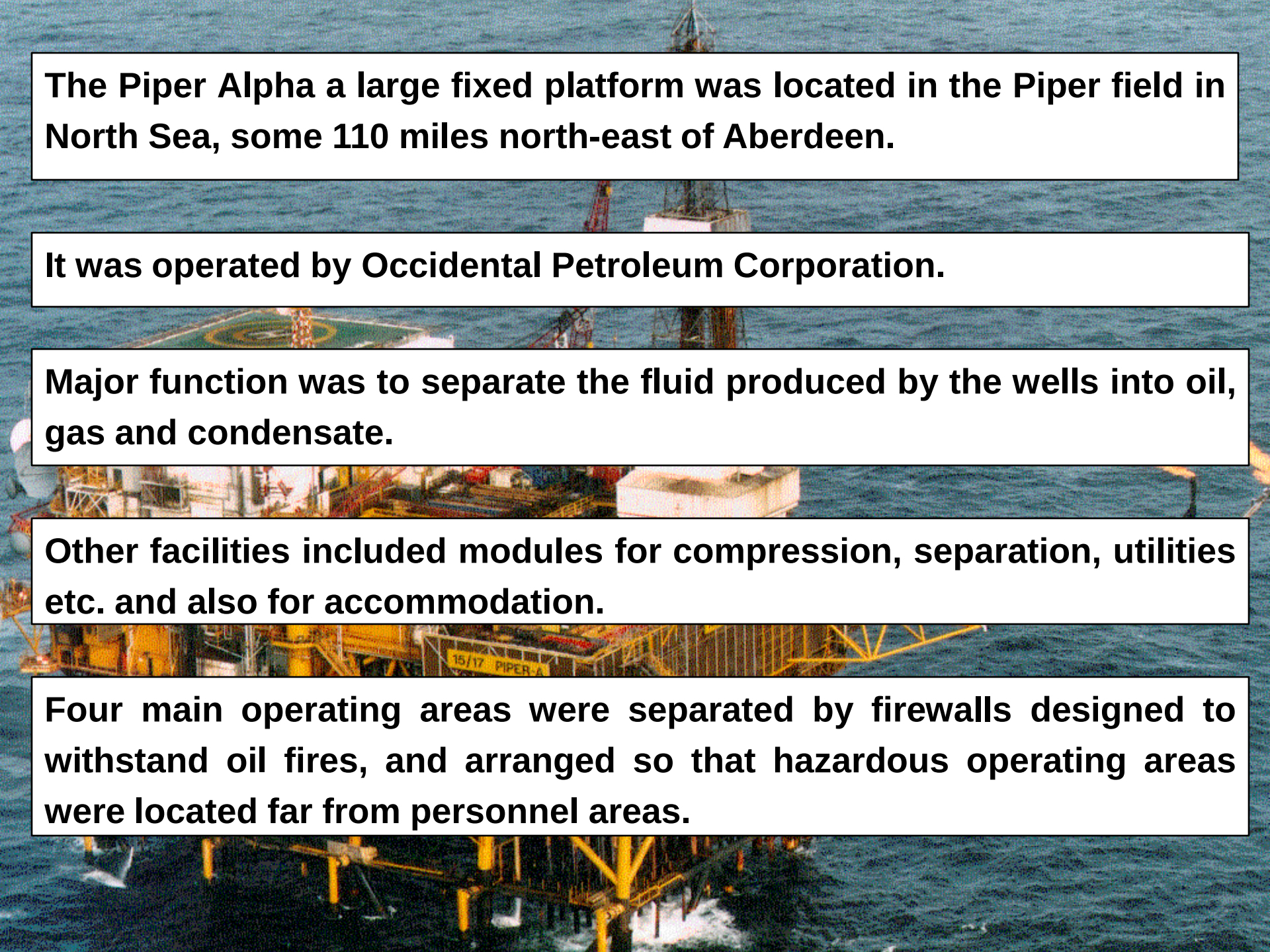
Why do Accidents Happen?

- **Equipment**
  - **Breakdowns**
  - **Doesn't work**
- **People**
  - **Incompetence**
  - **Sloppiness**
  - **Risk Taking**
- **Organisation**
  - **Allowing failures to propagate**
  - **Accidents waiting to happen**

Piper Alpha


Brief about Indian Oil
Petroleum Industry Hazards
Causes of Accidents
Piper Alpha
San Juanico Mexico
Way Forward

Piper Alpha, 1988



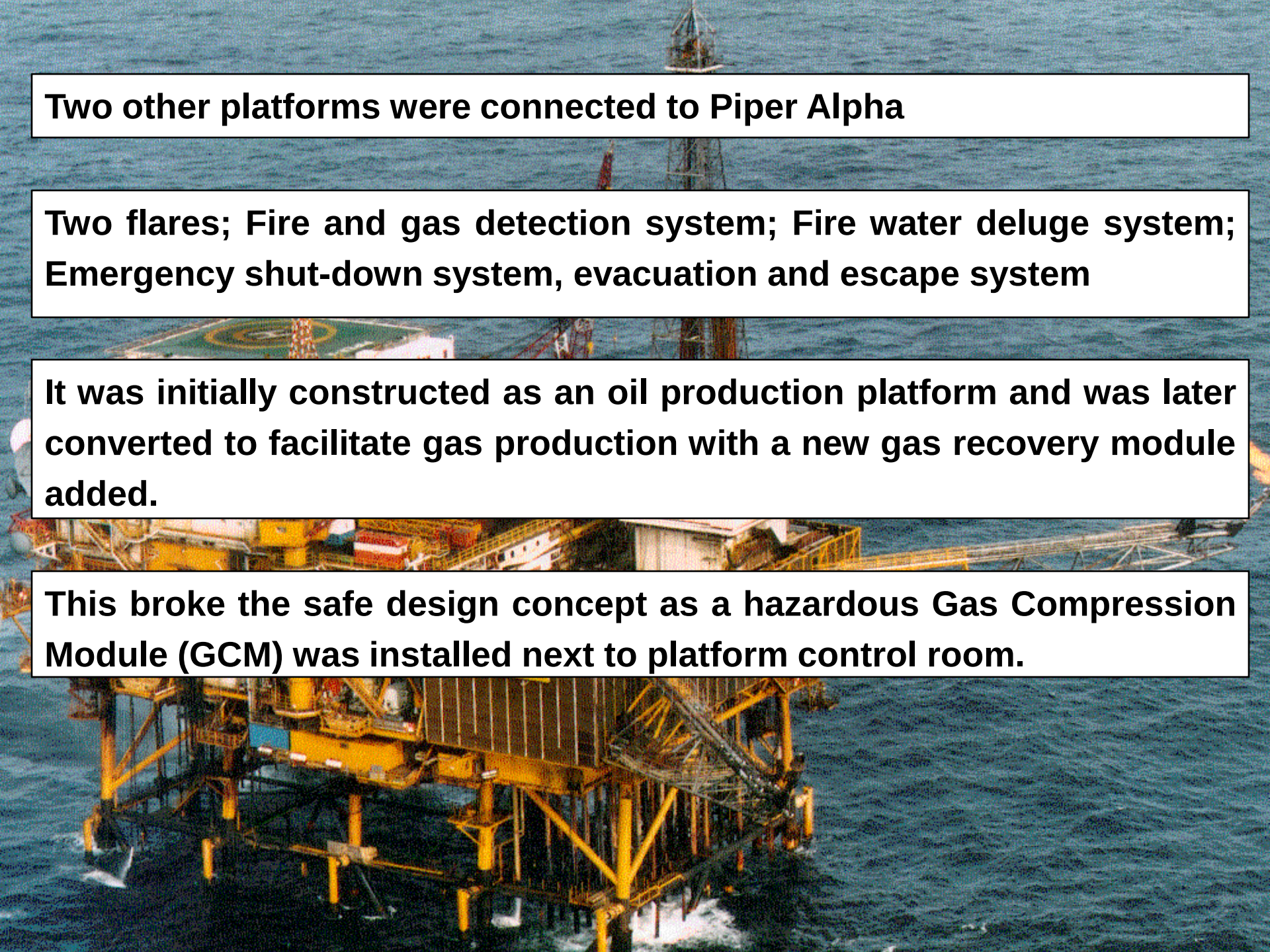
The Piper Alpha a large fixed platform was located in the Piper field in North Sea, some 110 miles north-east of Aberdeen.

It was operated by Occidental Petroleum Corporation.

Major function was to separate the fluid produced by the wells into oil, gas and condensate.

Other facilities included modules for compression, separation, utilities etc. and also for accommodation.

Four main operating areas were separated by firewalls designed to withstand oil fires, and arranged so that hazardous operating areas were located far from personnel areas.

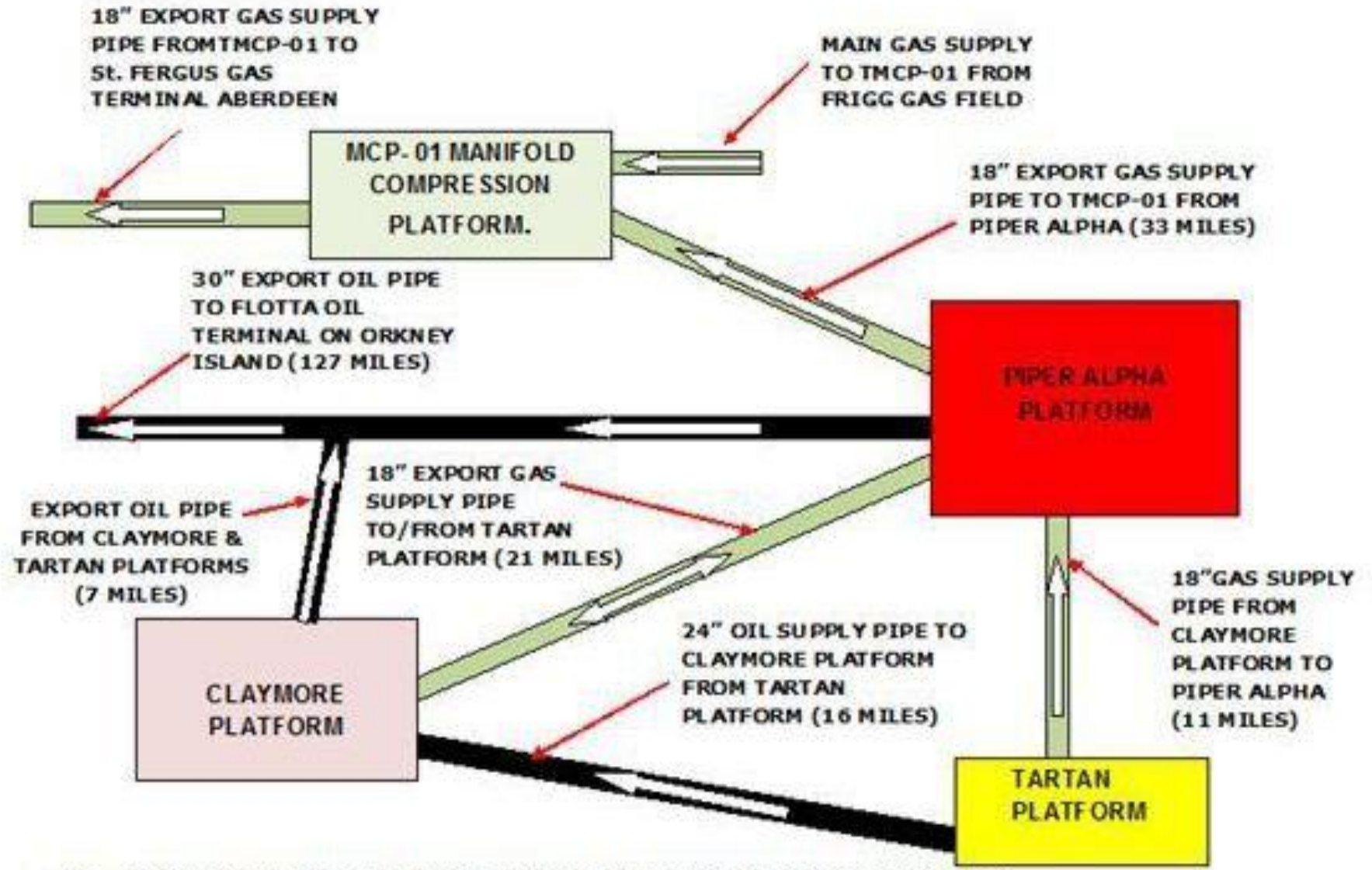


Two other platforms were connected to Piper Alpha

Two flares; Fire and gas detection system; Fire water deluge system; Emergency shut-down system, evacuation and escape system

It was initially constructed as an oil production platform and was later converted to facilitate gas production with a new gas recovery module added.

This broke the safe design concept as a hazardous Gas Compression Module (GCM) was installed next to platform control room.



OIL AND GAS PIPELINES BETWEEN PIPER ALPHA OTHER PLATFORMS

Drawn by Willie Scott 24/04/2011

Piper Alpha

- At 1000 pm on 6th July 1988, an explosion occurred in the gas compression module.
- 167 persons died, mostly in the quarters. 62 men escaped mainly by climbing down knotted ropes or by jumping from a height.
- Most casualties because of suffocation caused by carbon monoxide and fumes in the accommodations area.
- The total insurance loss was estimated about $3.4 Billion.
- Deadliest offshore oil industry disaster.

Events prior to explosion

- Two pumps for condensate injection to the coast - A & B.
- Pump B was in operation for condensate injection.
- Pump A was under maintenance for
  - Preventive Maintenance
  - Repair of pump coupling
  - Rectification of Pressure Safety Valve (PSV)
- PSV was removed for maintenance and the worker used a blind flange (hand-tightened) to seal off the open pipe.
- Work on PSV was started but the work on Pump was not taken that day.

Events prior to explosion

- The PSV was taken off on 6th July morning by a two-men team from the specialist contractor but could not be restored by that evening.
- In the evening, the supervisor suspended the permit-to-work and the team then went off duty, intending to put the PSV back the next day.
- Supervisor stated on the permit that pump A was not ready for operation and must not be activated.
- The permit was placed in a box near the valve, as the location based permit had outlined.

Events prior to explosion

- At about 9.50 pm, pump B tripped, due to hydrate buildup that blocked the GCM, and could not be restarted.
- If the pump would not be immediately started, flash drum level will increase and within 30 minutes shut down of the gas plant had to be taken.
- There was a possibility that if the gas supply to the main generator was lost and if the changeover to the alternative diesel fuel failed, the wells also have to be shut-down. It would then be necessary to undertake a ‘black start’.

Events prior to explosion

- It was decided to start Pump A.
- Pump A overhaul permit was found (which was not taken up), but operator could not find the permit related to its PSV maintenance job.
- No mention of PSV job during shift changeover.
- Believing it was safe to start pump A, the operator activated it at 9:55 pm.
- High pressure gas leaking through the hand-tightened failing blind flange whistled and triggered alarms.
- At about 9.55 pm, signals for tripping centrifugal compressors came to the control room. Thereafter, a group of alarm came up. The operator had his hand out to cancel the alarms when he was blown across the room by explosion.

Explosion

- Initial explosion occurred at 10.00 pm.
- Followed almost immediately by a large fireball and large oil pool fire.
- The oil pool fire gave rise to a massive smoke plume. The escape routes from the module to the lifeboats were impassable.
- The fire water drench system did not operate because it was kept in manual in view of safety of divers as there was a possibility of divers getting sucked in due to pump pressure.

Explosion

- The explosion disabled the main communication system which was centered on Piper.
- Occidental issued no orders to either Tartan or Claymore to shut down and operators believed they did not have authority to stop export from Piper Alpha, though they could see the Piper burning.
- So other platforms continued production and pumping of gas for sometime which supplied additional fuel to the fire at Piper.
- At 10:20 pm, Tartan's gas line burst, feeding around 33 tones of gas per second into Piper Alpha, which ignited immediately.
- Helicopter rescue was impossible because of the wind, smoke, and flames.

Explosion

- The Tharos, a fire fighting vessel attempted to draw alongside Piper Alpha and fight the inferno at 10:30 pm, but was restricted as its water cannons possessed enough pressure to kill platform workers if hit directly.
- At 10:50 pm, second gas line from MCP-01 platform ruptured feeding more gas into the fire.
- Due to high flames, steel rig and portions of Tharos started melting.
- At 11:20 pm, the melting utilities module and crew quarters slid into the sea.
- The rest of the platform followed piece by piece until 12:45 am, July 7, 1988.

Fire on the Platform before riser rupture

Fire on the Platform after riser rupture

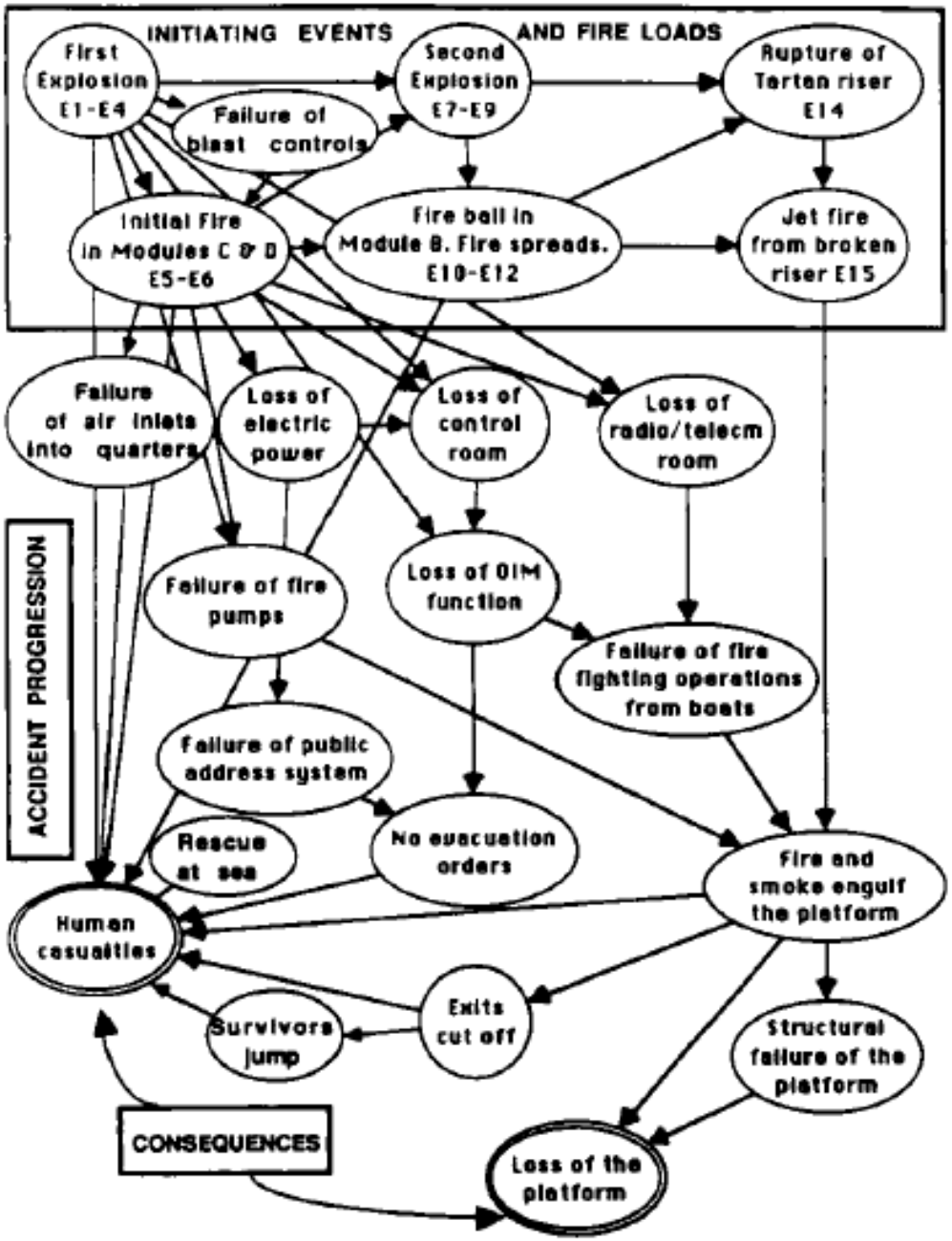
Figure 2. The smoke reached hundreds of feet above Piper Alpha, preventing rescue helicopters from approaching. Source: Technologism.net.

Effects of explosion

The entire deck was destroyed. By the morning of 7th July only the oil wells module remained standing.

Figure 3. The remaining oil wells module continued to burn for weeks until famed firefighter, Red Adair, and his team extinguished the remains. Source: BBC.

Sequence of Events



Investigation

- **Investigated by Lord Cullen, a Scottish judge.**

- **Piper Alpha Report concludes**

  - Fuel : Condensate leaked from the PSV line of pump A from which the PSV was removed for maintenance.

  - Ignition source could not be identified.

  The lead operator who went to start pump A was not aware that its PSV has been removed for maintenance.

Investigation

- **The contractor supervisor who suspended the permit was on his first job and did not have any training in the operation of permit to work system.**

- **It appears that the production operator also did not inspect the job site.**

Some critical findings

- Regulatory control is not enough for safety.
- Defective work permit system and violation of existing code of practice for work permit system
- Positive isolation for maintenance not followed
- Safety audits failed to reveal the weakness of work permit system.
- Failure to maintain correct records.
- Inadequate training for operations and emergency response
- Protection system and communication system was disabled in explosion.
- Absence of change management system.

Some critical findings

- Contractor supervisor was not trained on work-permit system.
- Production supervisor did not inspect the job site.
- Operating personnel were under pressure to avoid ‘black start’
- Failure in handing over procedure.
- The continued pumping of gas and oil by the Tartan and Claymore platforms was not shut down due to a perceived lack of authority, even though personnel could see the Piper burning.

San Juanico Mexico

San Juanico, Mexico 1984

PEMEX LPG Terminal - San Juanico, Mexico

- **LPG Storage Capacity – 16,000 M3**
  (6 Horton spheres and 48 Bullets)
  Inventory at site when accident began – 11,000 M3
  Area of site – 13,000 M2 (approx 3 acre)

- **At about 0535 hours on 19th November 1984, a major fire and a series of explosions occurred at PEMEX LPG Terminal.**

Around 650 people were killed

5000-7000 severe injuries

10,000-60,000 people made homeless

31 million dollars of damages

Terminal destroyed. Destruction of 1/3rd of the LPG supply to Mexico City

What happened - Mexico

- Vessels at the PEMEX terminal were being filled with LPG arriving in a pipeline from a refinery 400 kiolmeter away.
- About 0530 hours, 8 inch feed pipe near the vapor phase of Horton Sphere F-4 ruptured causing release of LPG.
- Official cause of rupture is unknown
- One report cited
  - Overfilled sphere caused the inlet line to rupture
  - Failure of relief valve
- Other cause is possibility of water hammer hitting the 8 inch feed pipe near the vapor phase of F-4 causing its rupture.

What happened - Mexico

- **Release of LPG continued for 5-10 minutes. People in the nearby housing heard the noise of escape and smelled the gas.**
- **Gas cloud (200x150 m, height 2 m) found the flare and got ignited at 0540 hours.**
- **The cloud caught fire over a large area, giving a high flame and causing violent ground shock.**

What happened - Mexico

- At 0545 hours, the first BLEVE occurred. About a minute later another explosion occurred, one of the two most violent during the whole incident.
- One or two of the smaller spheres BLEVEd, giving a fire ball of 300 m diameter
- A rain of LPG droplets fell on the area. Surfaces covered in the liquid were set alight by the heat from fireballs.

People burned like torches.

What happened - Mexico

- **Series of explosions followed as vessels suffered BLEVE. 19 explosions over a period of one and half hour.**

- **Numerous missiles generated by the bursting of vessels. Many of these were large and traveled far.**

- **25 large fragments (Weight 10 - 40 tonnes) - found 100-890 m away.**

What happened - Mexico

15 bullets weighing 20 Tonnes became missiles and rocketed over 100 m, one traveling 1200m.

4 Bullets were not found at all.

19th November, 1984

0530	Rupture of 8 inch pipe. Fall of pressure in control room.
0540	Ignition of gas cloud. Violent combustion and high flame.
0545	First explosion on seismograph, a BLEVE. Fire Department called.
0546	Second BLEVE, one of most violent.
0600	Police alerted and civilian traffic stopped.
0630	Traffic chaos.
0701	Last explosion on seismograph, a BLEVE.
0730	Continuing Bullet explosions
0800-1000	Rescue work at its height.
1100	Last Bullet explosion
1200-1800	Rescue work continues.
2300	Flames extinguished on last large sphere.

Mexico – PEMEX LPG Terminal

A BLEVE(From a distance of 1350 m)

A BLEVE. (spot 5, at a distance of 1350 m)

Series of explosions / fires

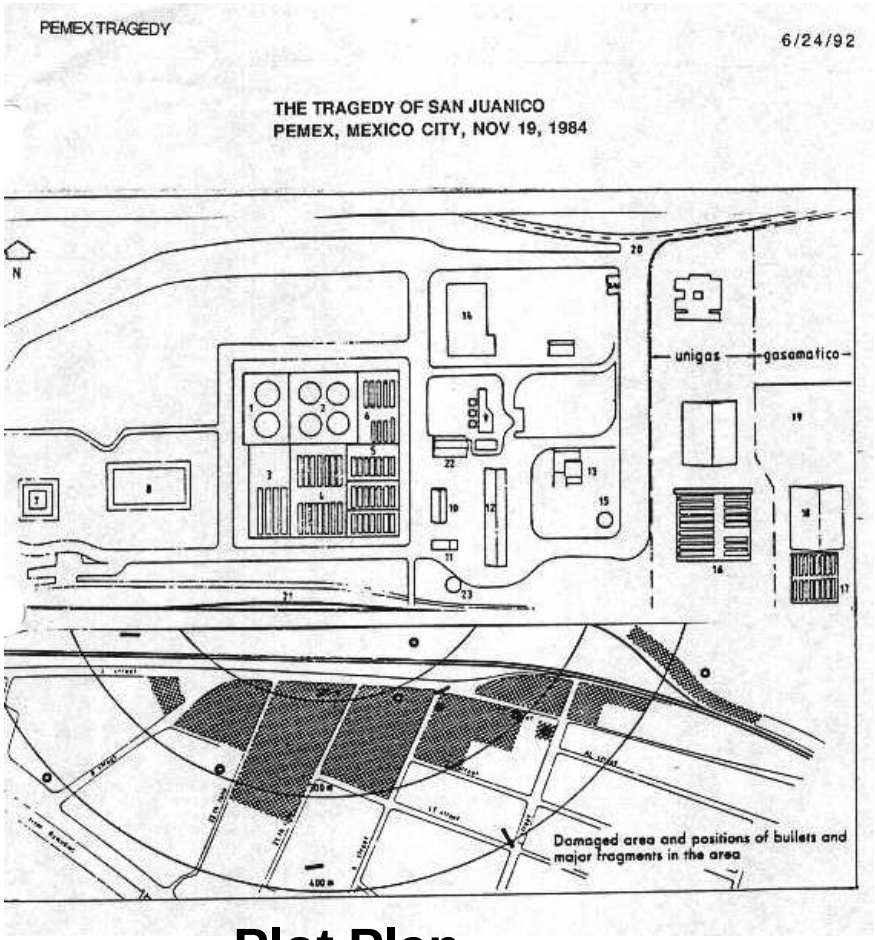
Fatalities 500,
Terminal destroyed

@NJS/SEAS/CS/2004/ 7

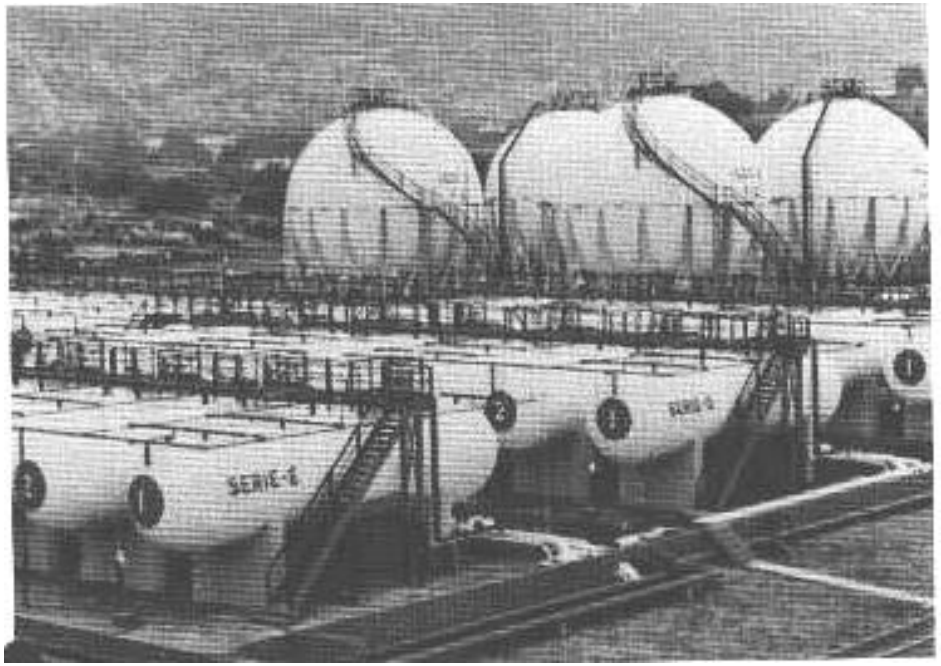
Mexico – PEMEX LPG Terminal

The Installation about 1979

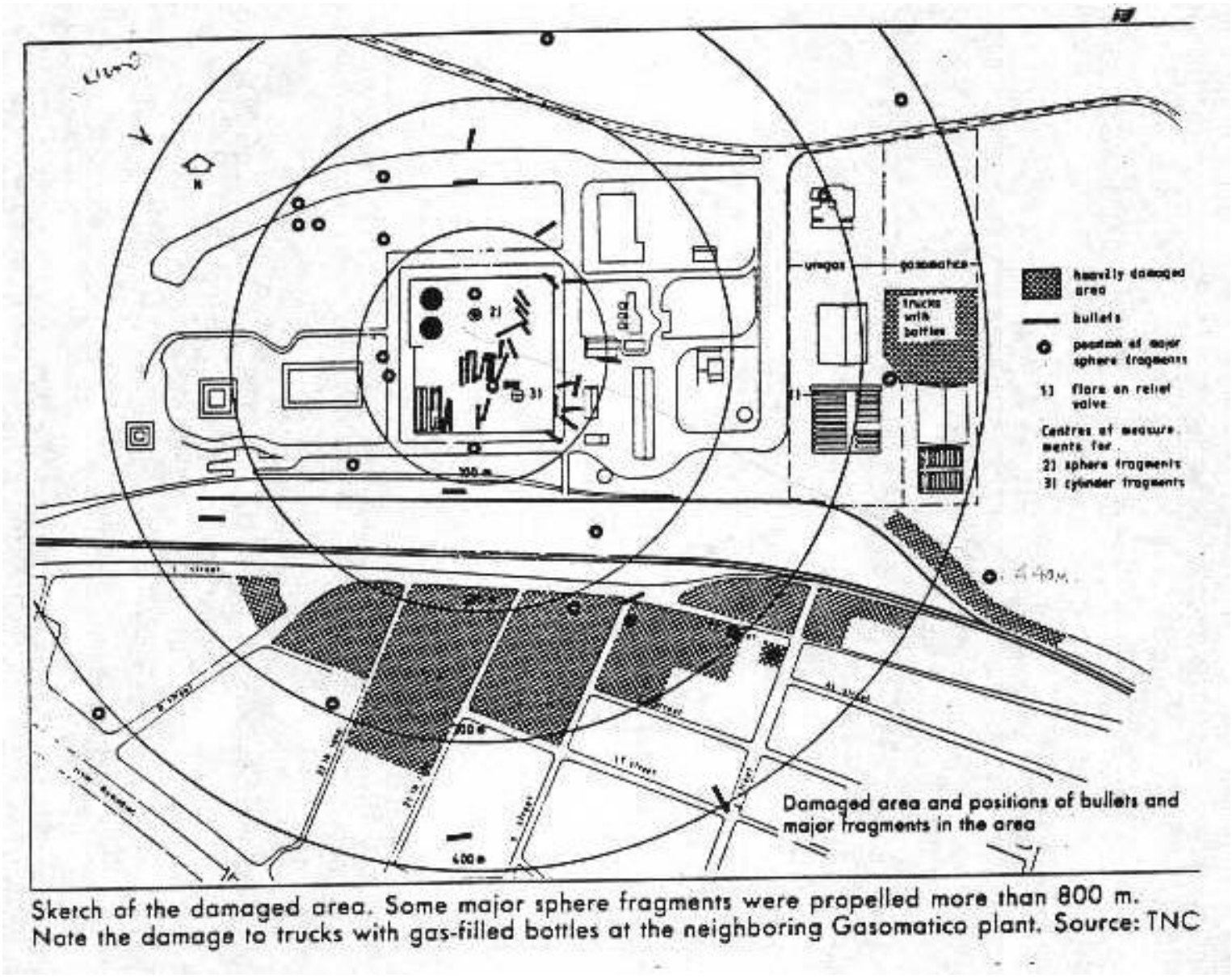
Pemex – Before BLEVE



Plot Plan

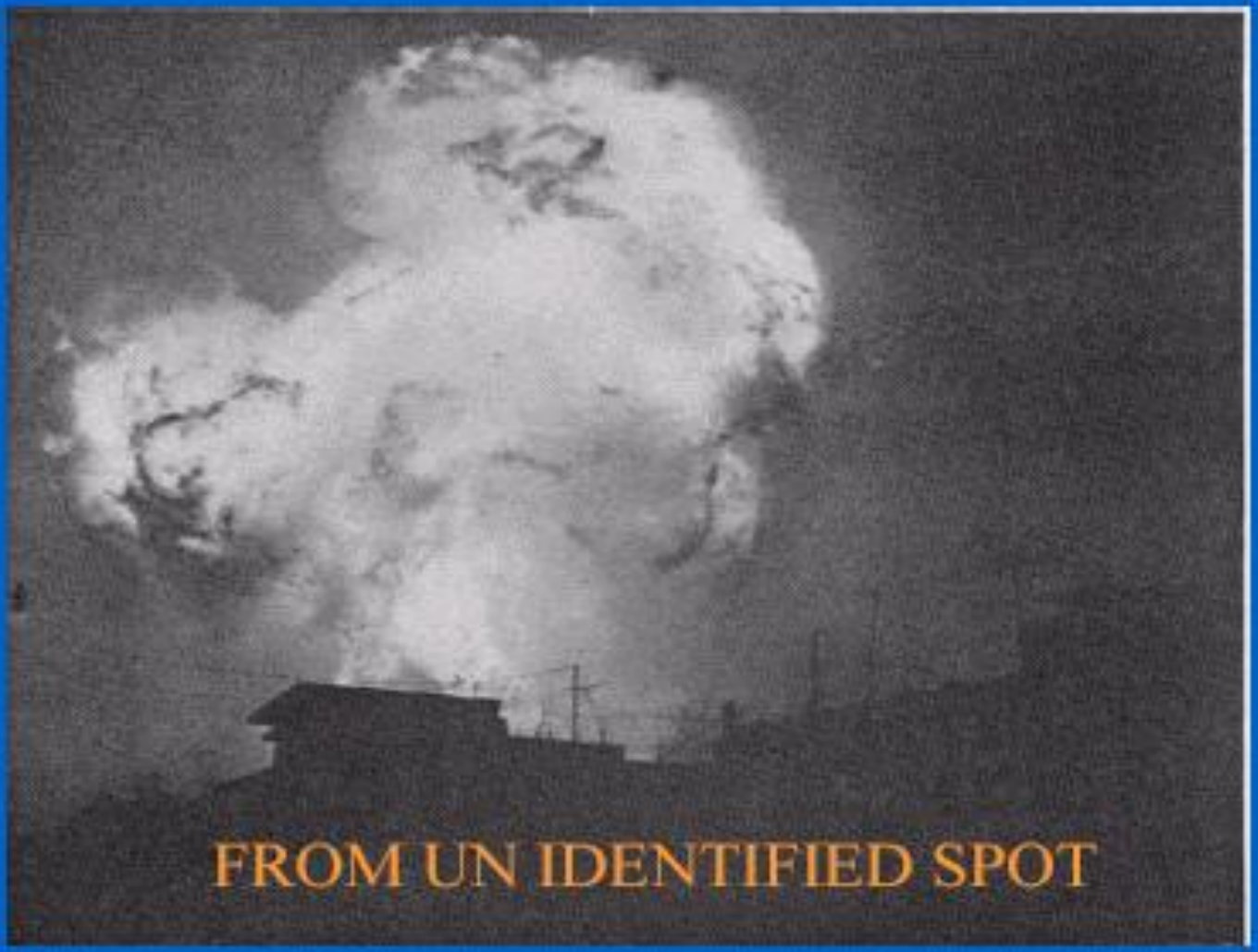


Plot Plan - After



Sketch of the damaged area. Some major sphere fragments were propelled more than 800 m. Note the damage to trucks with gas-filled bottles at the neighboring Gasomatico plant. Source: TNC

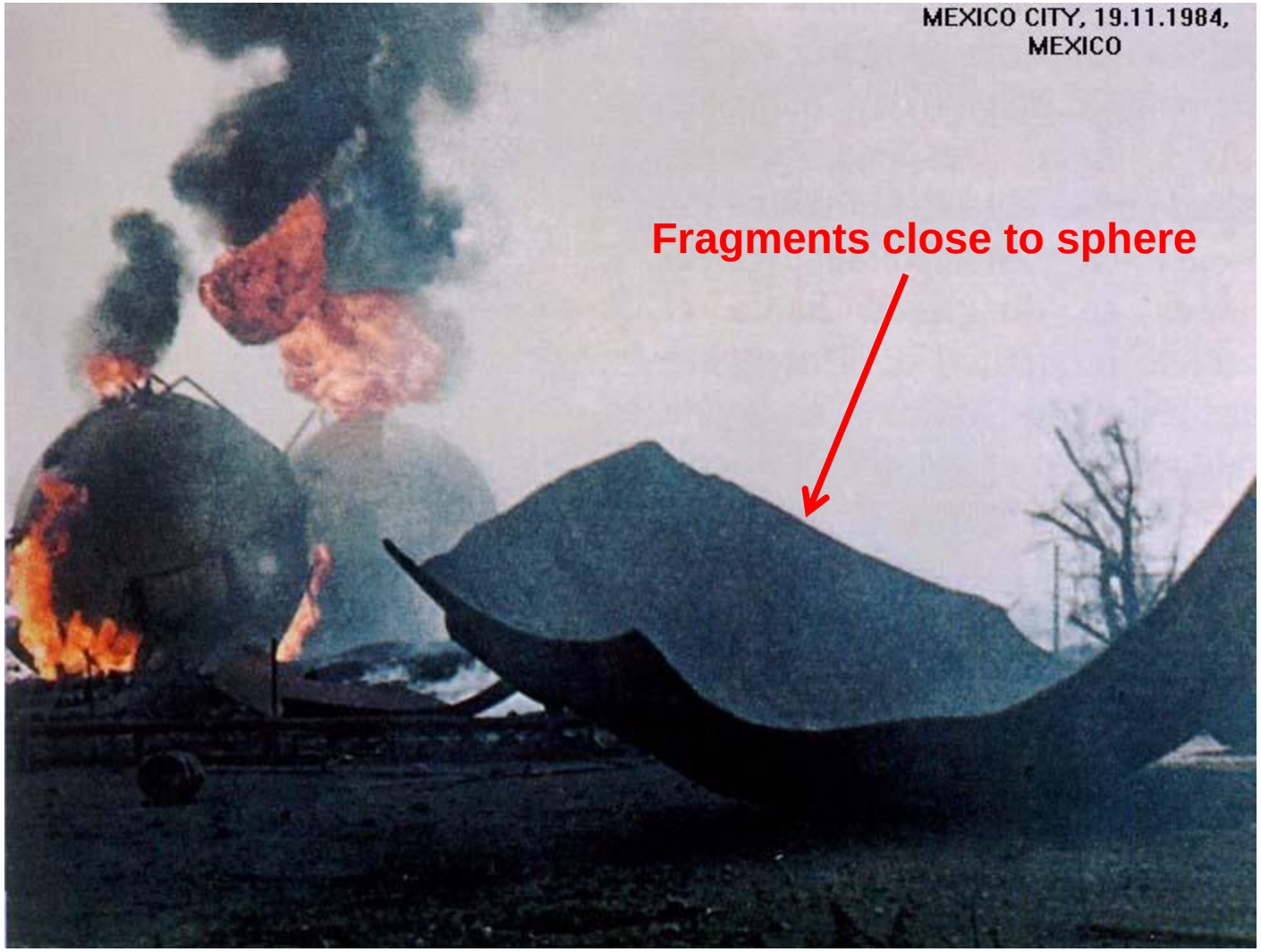
Another Fire Ball



Burning Site

Photo 3 Burning site

Mexico – PEMEX LPG Terminal



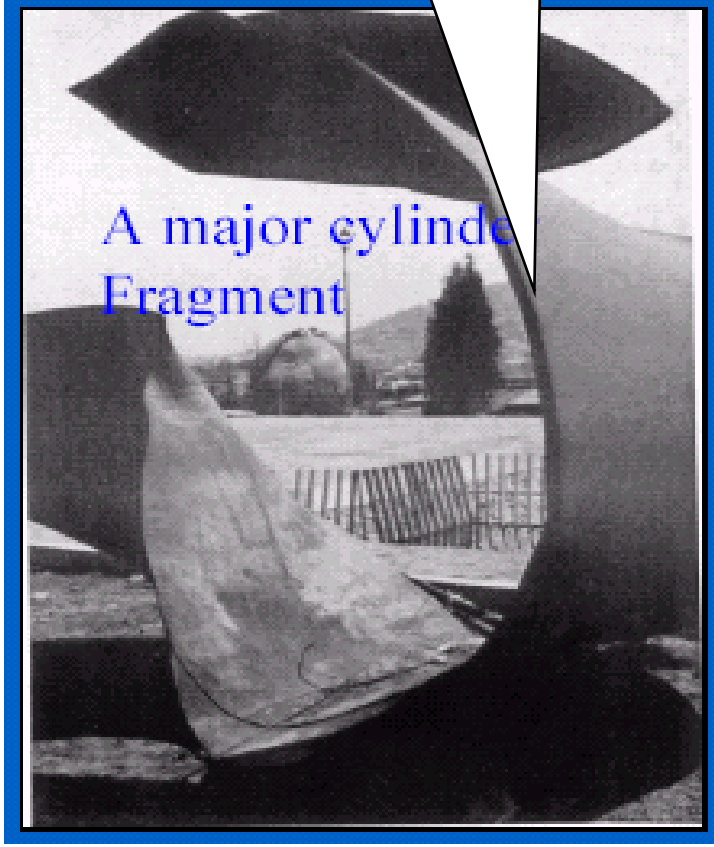
Mexico – PEMEX LPG Terminal

A Fragment in Copal Residential Area

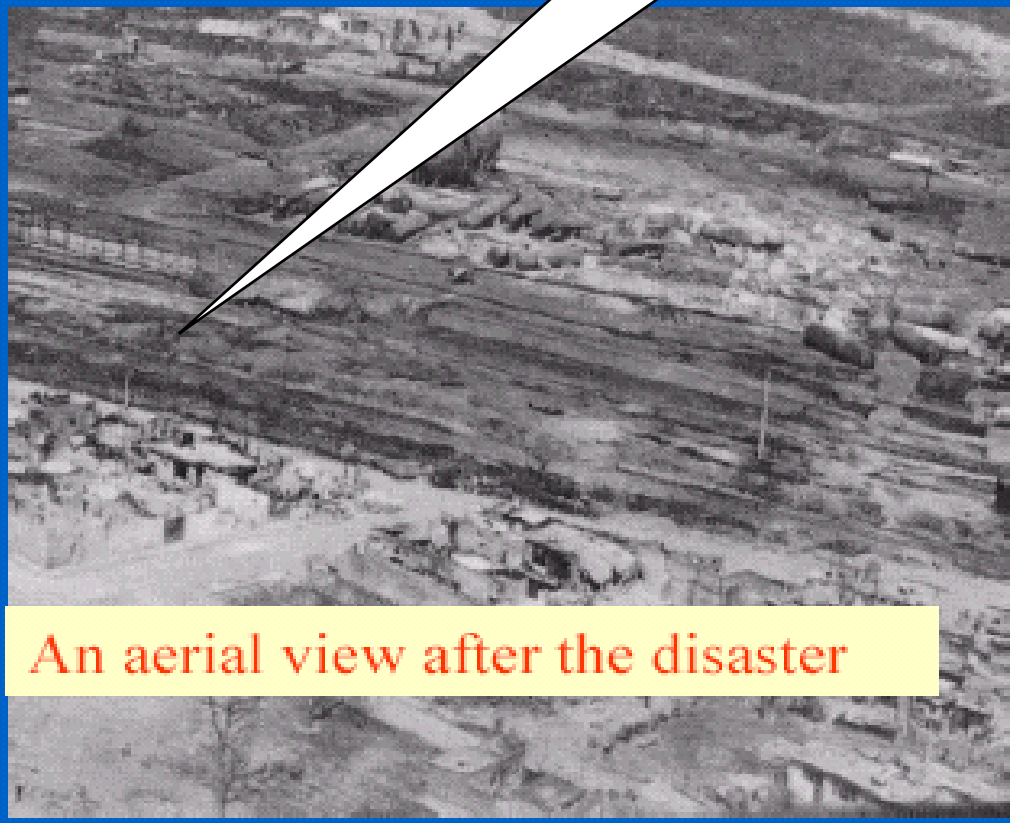
Mexico – PEMEX LPG Terminal

Aftermath

Major cylinder fragment



Aerial view after disaster



An aerial view after the disaster

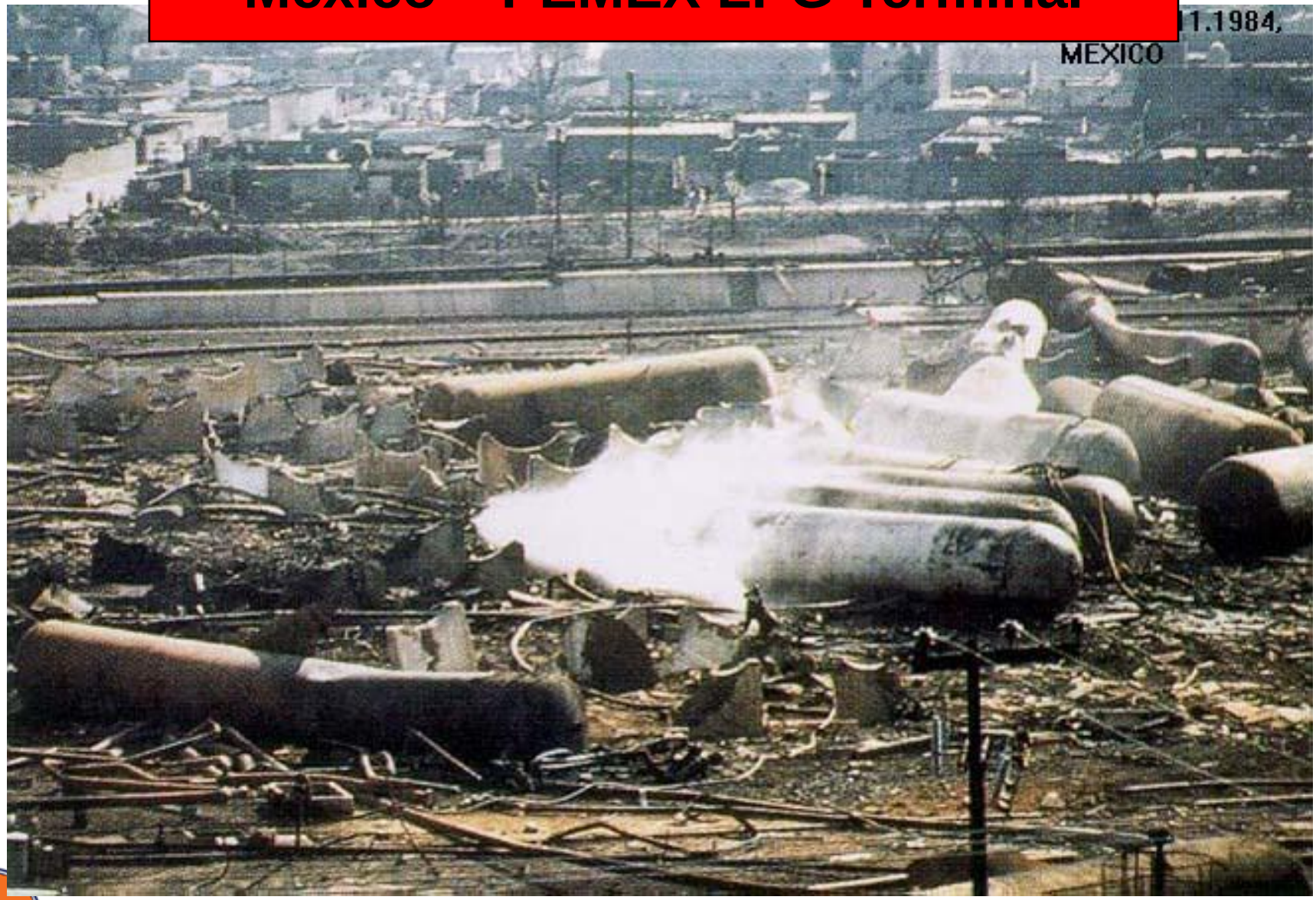
Mexico – PEMEX LPG Terminal

Destroyed Site

A burnt truck at site

A view of cylinder Area

Mexico – PEMEX LPG Terminal



Missile Alert

- **F1, F2, F3 and F4 spheres disappear.**
- **Avg. wt. of a bullet vessel was 20 tons.**
- **Furthest missile traveled 1,200 meters.**
- **Burning HCs rained on neighboring village 130m from fence line.**

Mexico – PEMEX LPG Terminal

The cylindrical tank that flew furthest penetrated some 1,200 m into the housing area and crashed into a 2 storey house vacated one hour before.

Mexico – PEMEX LPG Terminal

Nearby Houses

The desolation of the burnt-out houses recalled a war scene.

Mexico – PEMEX LPG Terminal

Injured people lying on streets

Emergency Response

- First firefighters arrive 15 minutes after first BLEVE.
- 100 ambulances and 200 firefighters involved.
- 985 medics and 1,780 paramedics involved.
- 1,332 medical volunteers in 33 hospitals involved.

Failings in Technical Measures

- **Plant Layout and positioning of vessels not proper.**
- **Emergency isolation means not available.**
- **The Terminal's fire water system was disabled in the initial blast. Also the water spray systems were inadequate.**
- **The installation of more effective gas detection system and emergency isolation system could have averted the incident.**
- **The Plant had no gas detection system and therefore when the emergency isolation was initiated it was probably too late.**
- **The traffic chaos hindered the arrival of emergency services.**

Lessons Learned

- **Old plant, too congested, poor maintenance & poor operator training were cited.**
- **Homes as close as 130m to plant. Village should have been 1,500 meters from terminal (determined by QRA analysis).**
- **Require many gas detectors and alarms.**
- **Emergency plan required.**

Way Forward


Brief about Indian Oil
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Way Forward

Way Forward

- Effective implementation of Work Permit System
- Implementation of Lockout Tagout System (LOTO)
- Effective Communication System and operator training
- Quantitative Risk Analysis to be carried out before setting up a new project. Housing appropriate distance away
- Management of Change to be adhered to.
- Timely inspections and better maintenance
- Maintain industrial standards
- Effective Disaster Management Plan in place. Planned evacuation routes

QUESTIONS