Accident Prevention & Learnings from Major Accidents in Petroleum Sector

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Outline

1. Incident Data
2. Analysis :Workplace safety Vs Process safety
3. Case studies & Learning from Major Incidents
4. Way Forward

Importance of safety in O&G Sector

- **Protection of Lives**: Ensures the safety of workers, contractors, and nearby communities, preventing fatalities and injuries.
- **Environmental Conservation**: Minimizes the risk of Oil spills, Toxic release, Gas leaks, and explosions that can cause severe environmental damage.
- **Asset Preservation**: Protects expensive infrastructure and equipment from damage, ensuring operational continuity.
- **Regulatory Compliance**: Adheres to strict safety regulations and standards, avoiding legal penalties and shutdowns.
- **Financial Stability**: Prevents financial losses from accidents, including damage costs, legal claims, and reputational harm.
- **Operational Continuity**: Reduces downtime caused by incidents, maintaining productivity and supply chain stability.
- **Community Trust**: Builds confidence among stakeholders, investors, and local communities by demonstrating a commitment to safety.
- **Reputation Management**: Enhances the company's public image.
- **Risk Mitigation**: Identifies and controls hazards to prevent accidents in a sector prone to fire, explosion, and toxic exposure.
- **Sustainability Goals**: Aligns with global efforts for sustainable and responsible energy production.

Incident Analysis of Indian Refinery & Petrochemical Installations : 2004-23

Refining and Petrochemical installations (42 Nos.)

Total 253 Incident

Period: 2004-2023

0600-1400
46%
1400-2200
35%
2200-0600
18%

2004-2023
Source: OISD

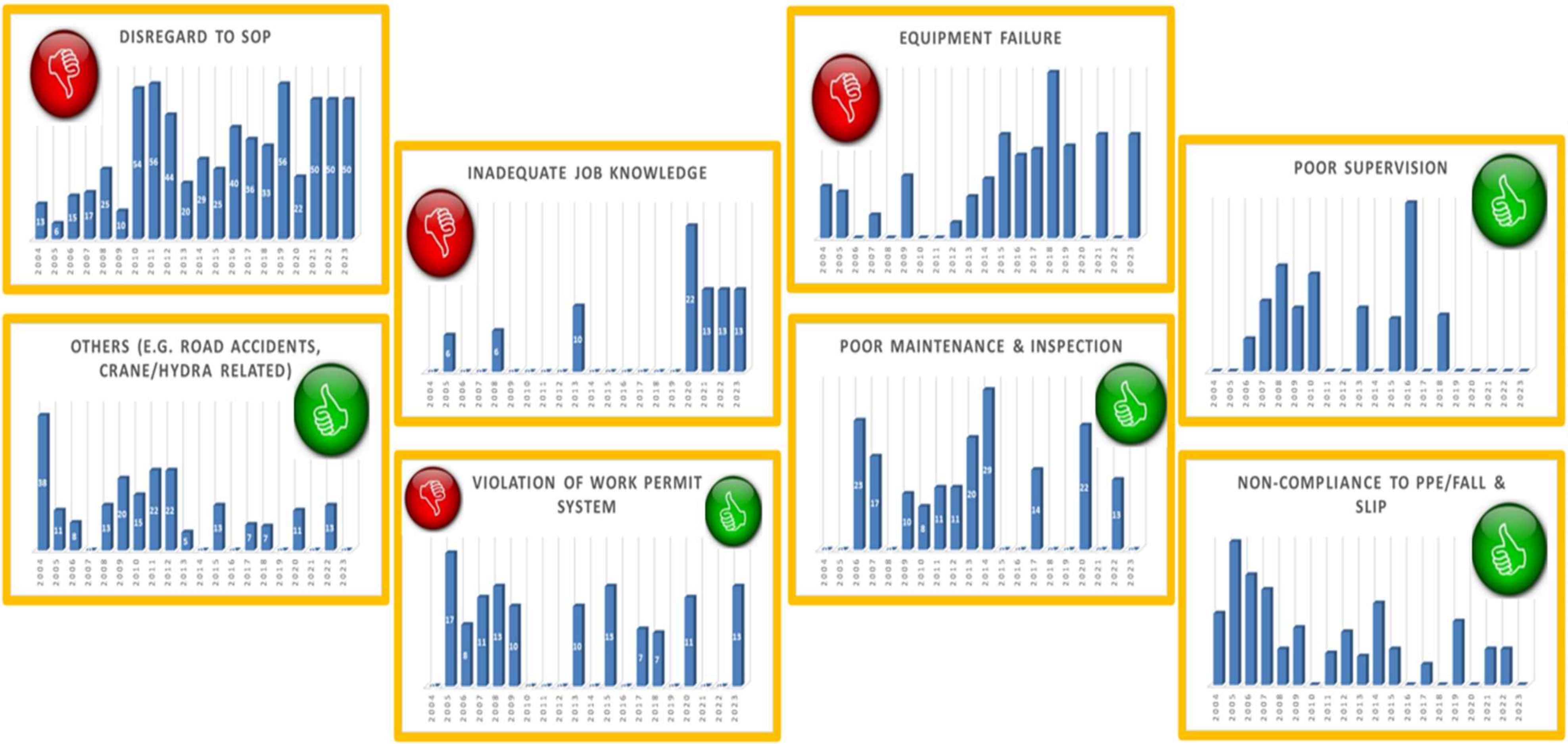
Total 227 Fatalities

Shut down/ Start up/ Project : 30%

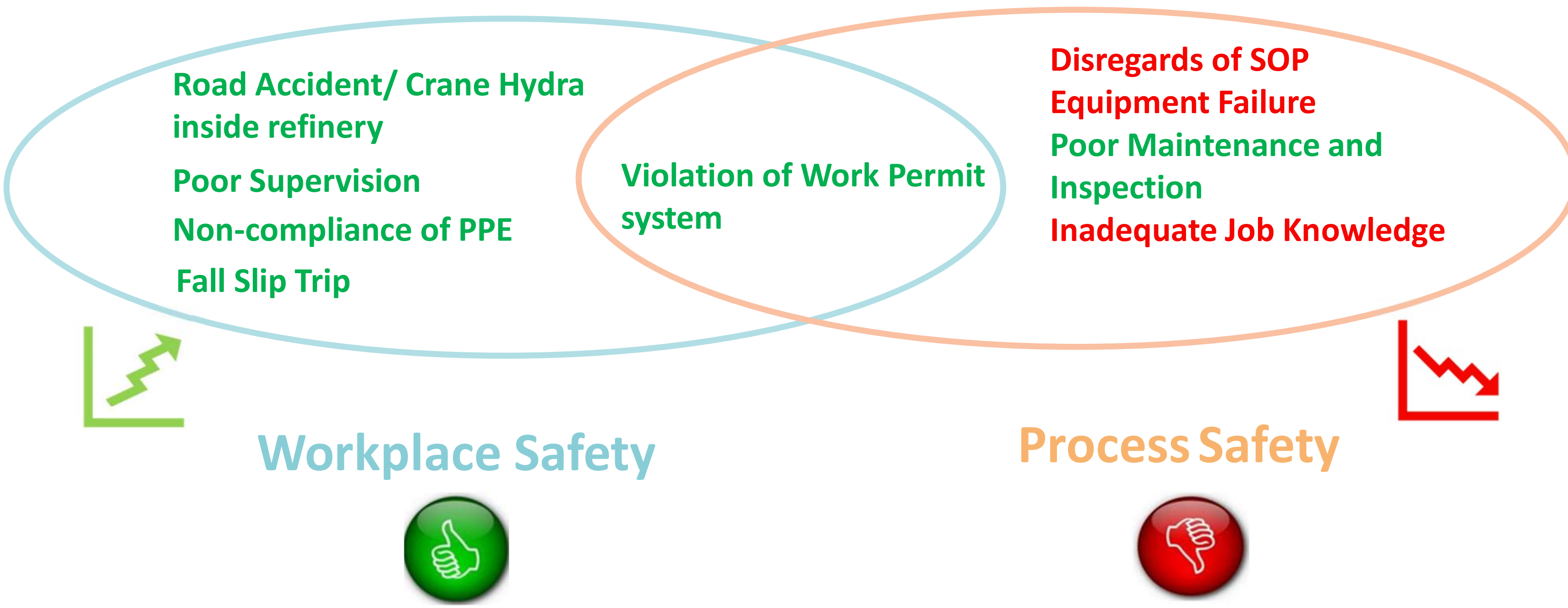
Fire: 162
Non fire: 91

Employee: 27
Contract Workers: 198

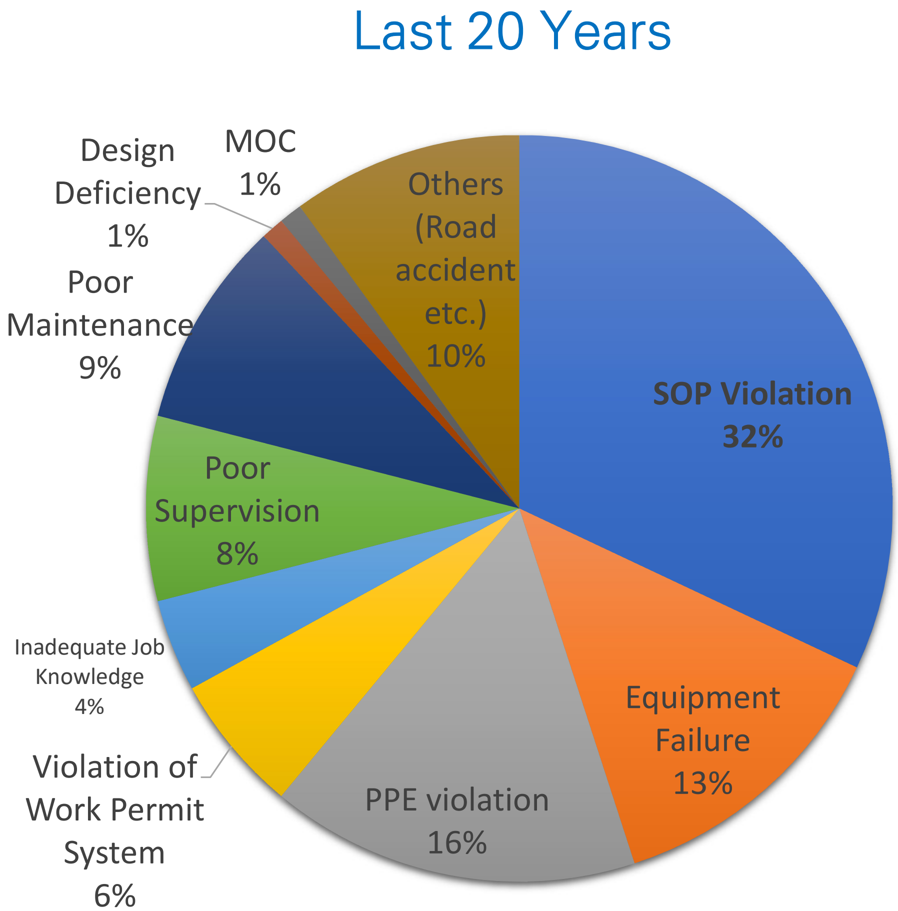
Anatomy of Causes of Incidents (2004-2023)

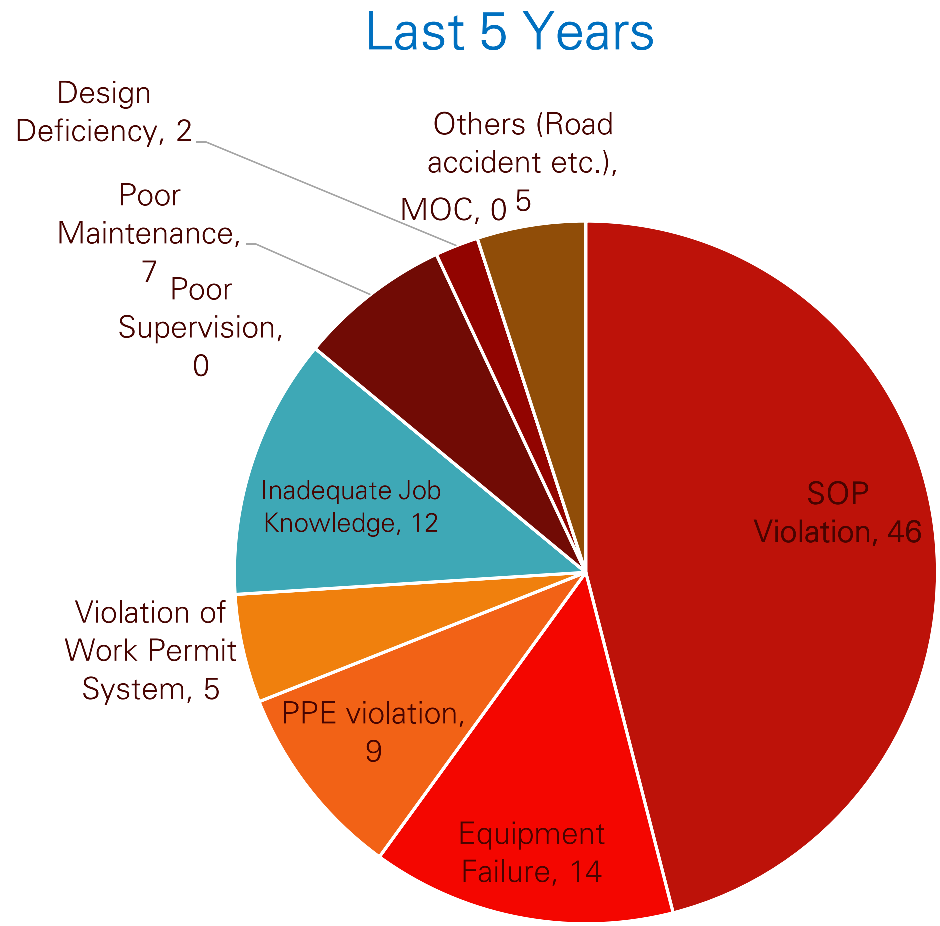


Workplace Safety Vs Process Safety



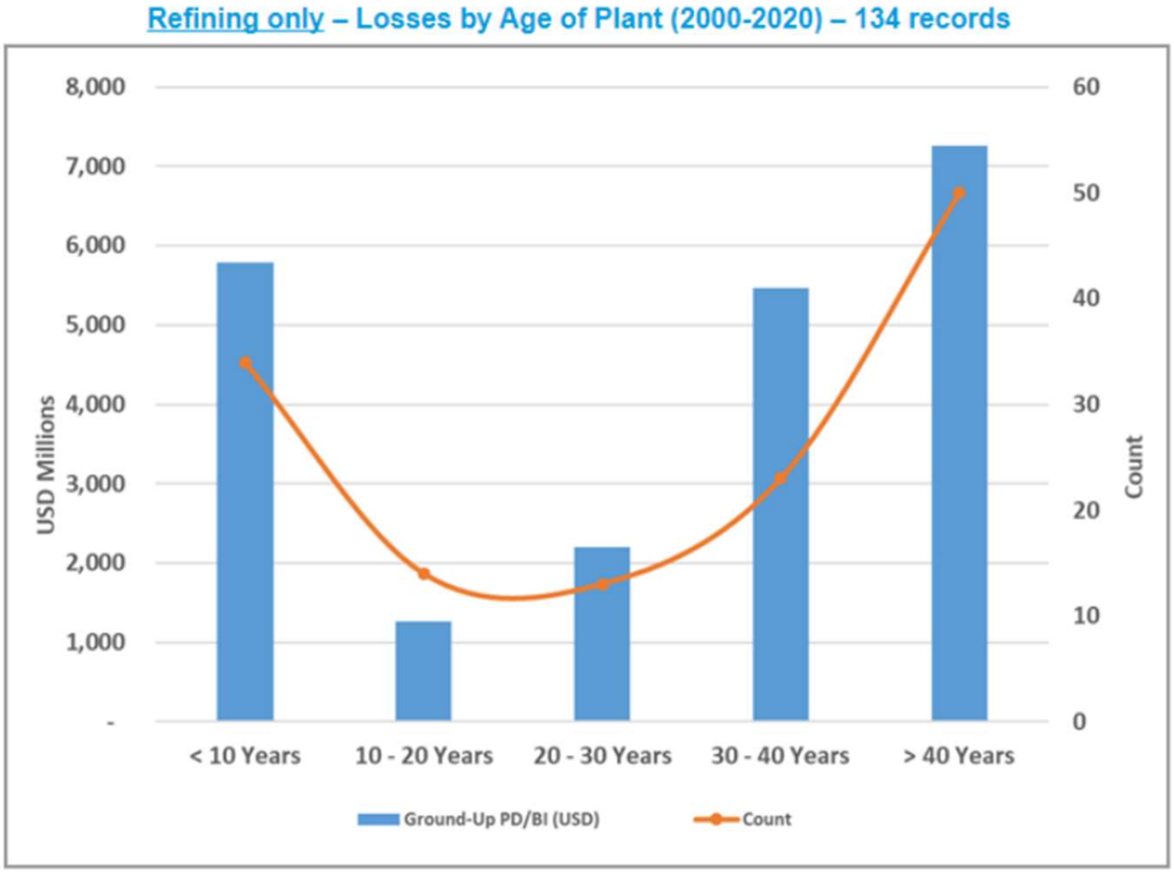
Incident Cause Analysis





Source : OISD

Age of plant
Vs
No of Incidents



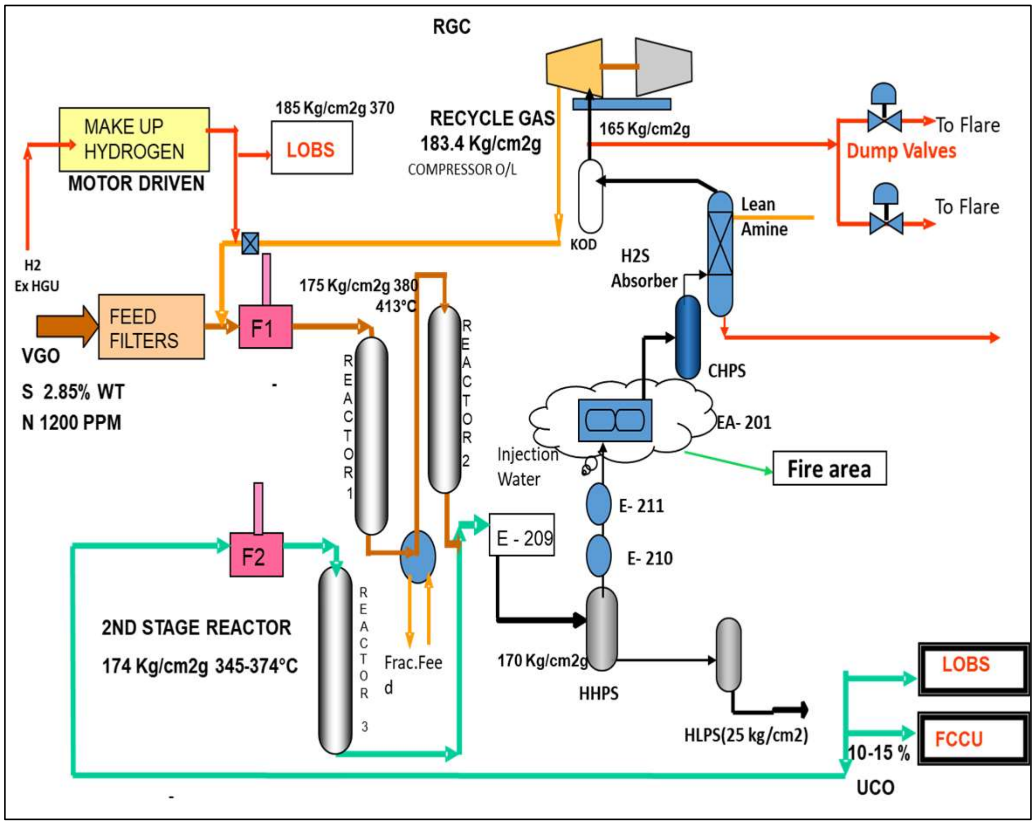
Data from Liberty Specialty Markets

Case studies & Learning from Past Incidents

HCU REAC EXPLOSION

- HCU REAC Failure/ Fire
- In many location /refineries
- Hydrocracker Unit
- **Cause : Sulphidation Corrosion/ Poor workmanship / Design issue (MoC)**
- **Preventive Measures : Upgrade of MoC to INCOLLAY 825 from KCS /SS Duplex**

The Incident- HCU REAC failure



Hydrogen followed by H2S alarm sounded indicating a leak at HCU REAC area.

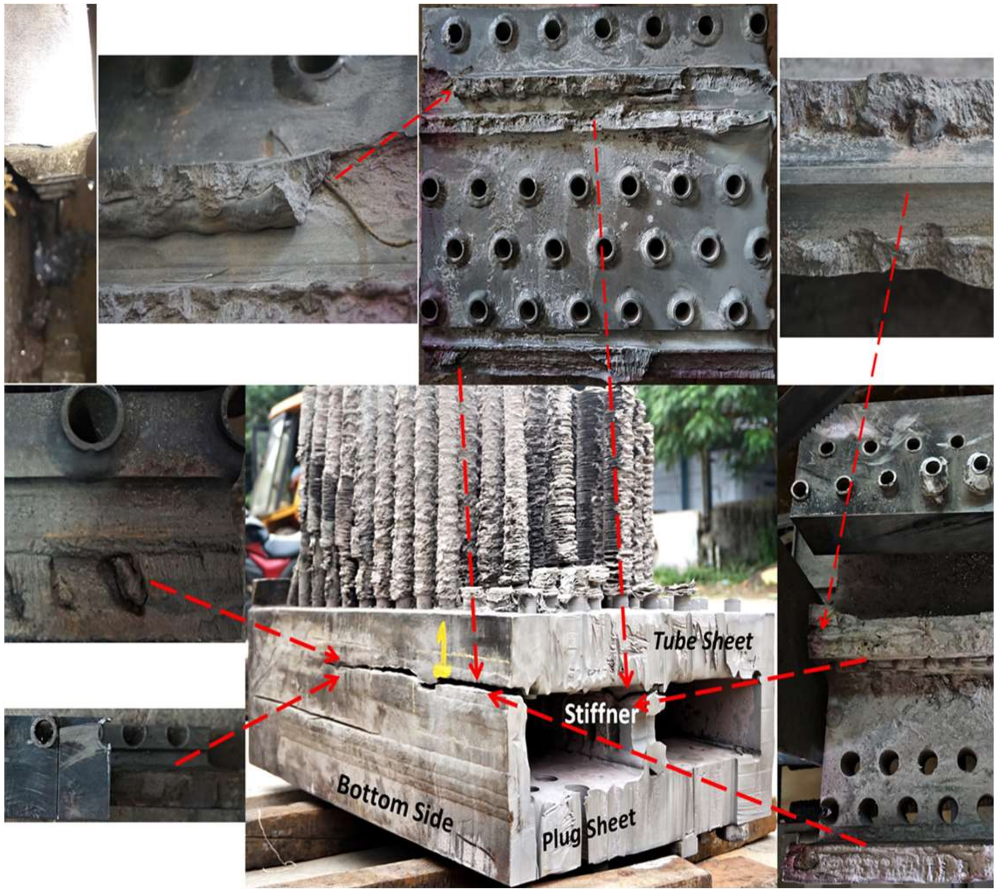
The leak aggravated with a sudden release of hydrogen and hydrocarbon mixture from 160 Kg/CM2.

Dump valve was operated to depressurize the system .

This vapour cloud got ignited and triggered shock wave for 2-3 Km in the surrounding area.

The Root cause

- **REAC AFCs are designed to operate in H2 and Sulphide atmosphere.**
- **Welding of the Duplex Stainless steels needs high precision welding by qualified welders as per approved welding procedure.**
- **Analysis showed welding was not done to the required quality even at the root level. At some weld locations there were carbon steel rods and wires used as filling along with the welds.**
- **The stiffener seems to have failed first due to improper welding.**
- **As a consequence of stiffener plate weld failure, the weld between bottom plate and tube sheet having stress concentration at the root in form of embedded carbon steel rod and wires resulted in the header box failure.**



Furnace Explosion

- **Explosion in furnace**
- **AVU**
- **Same cause : Disregards of SOP/ Purging not done**

Furnace Explosion

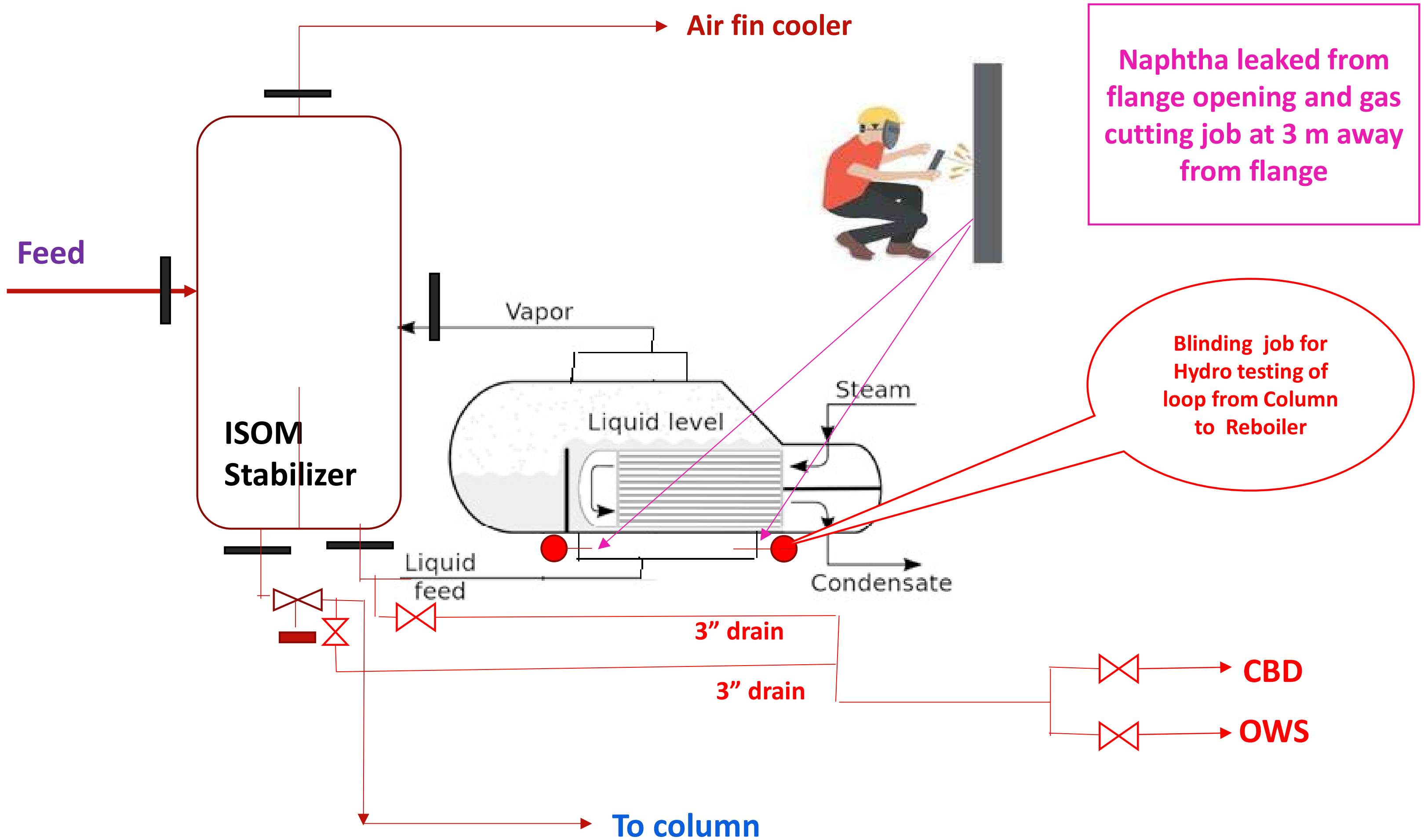
- Time & Date : About 10:38 Hrs. on 16 September,2021.
- After month long Turn Around (TA) shutdown, AVU was under start-up.
- During lit-up of vacuum furnace, explosion in furnace box took place.
- The incident caused damage to the furnace & injuries to employees & contract workers – (19 person injured 5 Employee & 14 Contract workers).
- Furnace shell got opened up from seam joint & refractory bricks got scattered in nearby area up to 30-40 meters.

Causes:

- Inadequate checking of furnace FG circuit line-up, leading to flow & accumulation of FG inside the furnace box prior to burner lit-up.
- Lack of proper monitoring and alert from DCS about FG flow into furnace prior to light up.
- Purging of furnace not done just before burner lit-up.

SOP not followed

Accident during Shutdown in MSQ Unit



Inadequate SOP

- No mention of Reboiler in Flushing Plan
- Flushing plans were not reviewed.

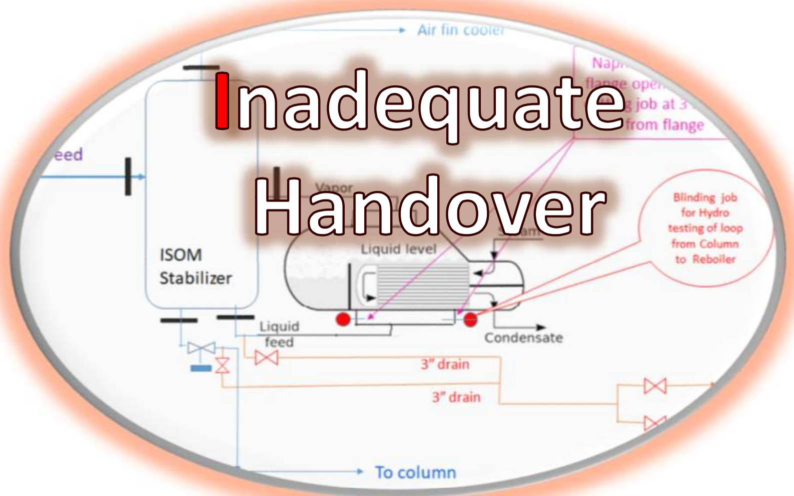
Inadequate Supervision

- No operating personnel present
- Simultaneous Hot job
- No area/ job assigned to operators

Pre-assumptions

- There was no job in Reboiler, hence no specific check points

Inadequate Handover



Inadequate communication

- No specific Work permit, no clearance
- No planning, No JSA for simultaneous job

Ignorance

- Naphtha leak during the blinding of column bottom lines 1 day before

Still Overflowing Tanks!

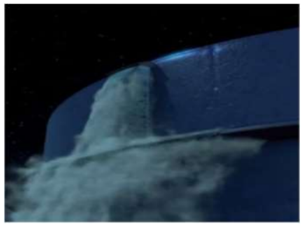
Multiple tanks burning in the fire

Fire at petroleum products storage facility in Puerto Rico, 2009

Damage to the facility after the fire

One of the reports of United States Chemical Safety Board (CSB) includes a list of 22 major tank farm fires from 1962 to 2009. 19 of the 22 incidents listed in the CSB report involved a tank overflow. **Tank overflow is a major contributor to such catastrophic incident.**

Unreliable instruments, inadequate procedures, and the lack of independent overflow protection systems on storage tanks were some of the significant operational and technical causes of the Puerto Rico incident, and likely for many of the other similar incidents.



Learnings :

Never underestimate the consequences of overflow of flammable, combustible, or toxic material from a tank!

Tank farm probably contains the largest inventory of hazardous material in the plant. If an incident occurs it is likely to be large.

Source : CCPS Process Safety Beacon

Case Study: Piper Alpha Disaster (1988)

❑ **Brief Description:**

The Piper Alpha oil platform, located in the North Sea, was one of the largest producers of crude oil in the region. On July 6, 1988, a massive explosion occurred due to a gas leak, leading to a catastrophic fire.

❑ **Impact**:

- ✓ 167 fatalities out of 226 crew members.
- ✓ Financial loss estimated at $3.4 billion.
- ✓ Considered one of the deadliest offshore oil industry accidents.

❑ **Root Cause:**

The accident was triggered by **gas condensate leakage** due to maintenance work on a PSV, which was not properly documented. When another worker unknowingly started the associated pump, the system failed, leading to the explosion.

Case Study: Piper Alpha Disaster (1988)

Lapses:

❖ **Permit-to-Work System Failure**:
- ✓ The maintenance and PSV replacement were not correctly logged.
- ✓ Critical communication gaps between shifts.

❖ **Inadequate Emergency Shutdown Procedures**:
- ✓ Failure to isolate the gas line completely before resuming operations.
- ✓ Inadequate safety barriers between gas and oil lines.

❖ **Poor Firefighting and Emergency Response**:
- ✓ Lack of training and preparedness for large-scale fires.
- ✓ Delayed evacuation led to higher casualties.

❖ **Design Flaws**:
- ✓ The platform's layout facilitated the spread of fire, as O&G lines were not sufficiently separated.

Key Learnings:

- **Robust Safety Management Systems (SMS)**:
  - Importance of maintaining comprehensive records of maintenance and operational tasks.
  - Need for a fail-safe permit-to-work system to prevent errors.
- **Emergency Preparedness**:
  - Regular training and drills for fire and emergency scenarios.
  - Advanced firefighting and evacuation infrastructure.
- **Design and Engineering Standards**:
  - Platforms should be designed to minimize fire spread (e.g., physical barriers between oil and gas systems).
- **Shift Handover Protocols**:
  - Effective communication between teams during shift changes to ensure continuity and safety.
- **Cultural Shift in Safety**:
  - Foster a safety-first culture, ensuring management commitment to enforcing stringent safety protocols.

Case Study: Texas City Refinery Explosion (2005)

Brief Description:

On March 23, 2005, a catastrophic explosion occurred at BP's Texas City refinery **during the restart of isomerization unit**.

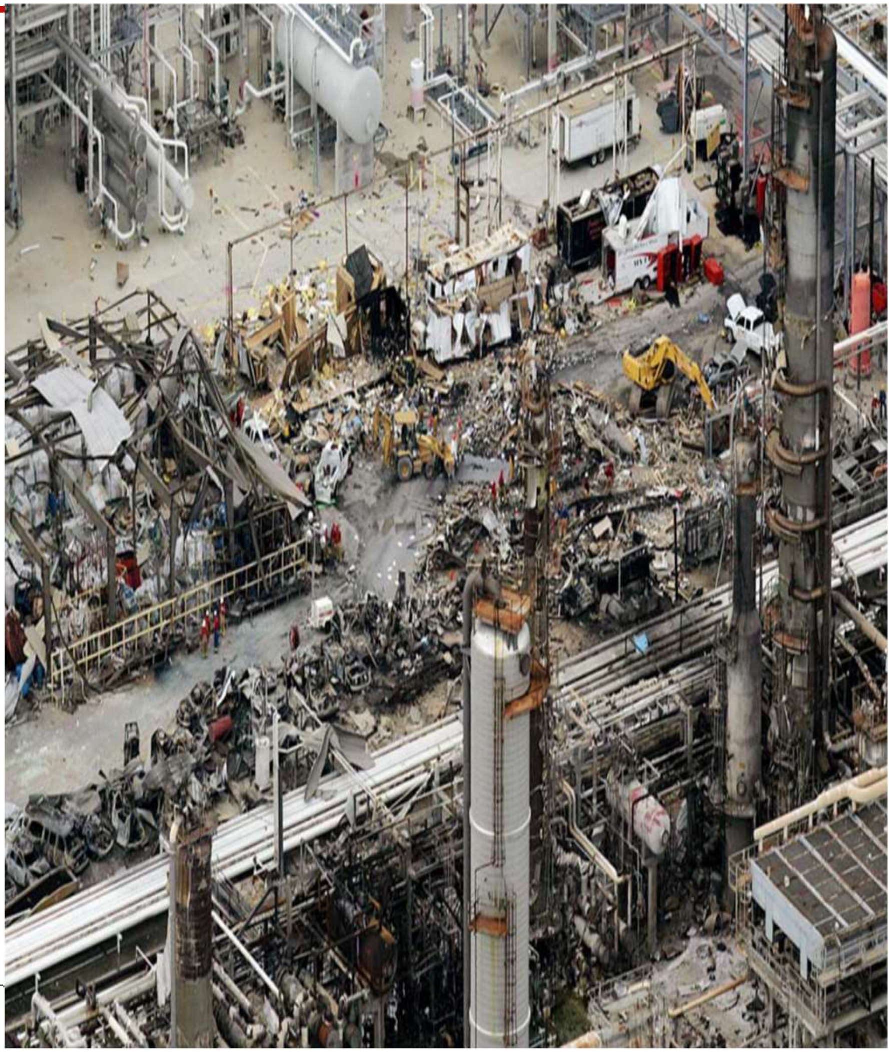
A release of flammable HC vapors led to ignition and a massive blast.

Impact:

- ✓ 15 fatalities and over 180 injuries.
- ✓ Extensive damage to the refinery and nearby areas.
- ✓ Financial losses exceeding $1.5 billion, with additional reputational damage to BP

Root Cause:

- Overfilling of a blowdown vessel with HC, leading to vapor release.
- The vent stack released a large quantity of flammable vapors into the atmosphere, which ignited due to nearby running engines.



Case Study: Texas City Refinery Explosion (2005)

Lapses:

Safety Systems Failures:

- The blowdown drum was outdated and lacked a flare system to safely vent excess hydrocarbons.
- Alarm systems were dysfunctional or improperly configured, failing to alert operators of the issue.

Cost-Cutting and Deferred Maintenance:

- Budget cuts and deferred upgrades left critical safety systems outdated and ineffective.
- Known hazards were not addressed despite previous warnings.

Inadequate Process Safety Management:

- Poor understanding and enforcement of safety protocols during unit restarts.
- Insufficient hazard analysis of the operation.

Safety Culture Deficiencies:

- Lack of management commitment to a safety-first approach.
- Employees and contractors reported feeling undervalued and reluctant to voice safety concerns.

Key Learnings:

•**Process Safety Management (PSM)**:

•Establish robust protocols for process safety, including hazard analysis and risk assessment, particularly during high-risk operations like restarts.

•**Alarm and Monitoring Systems**:

•Ensure alarms are functional, properly configured, and tested regularly.

•Equip operators with real-time monitoring tools to detect anomalies promptly.

•**Promote a Safety-First Culture**:

•Encourage reporting of safety concerns without fear of reprisal.

•Management must demonstrate commitment to prioritizing safety over cost.

•**Training and Competency**:

•Enhance operator training to improve understanding of safety-critical systems and operational risks.

•Conduct regular drills to ensure preparedness for emergencies.

Warning Signs for Catastrophic incidents in O&G Installations

Leadership and Culture

- Management and workers either not aware or not committed to safety standards and lack of enforcement of applicable standards and rules
- Poor housekeeping in production areas and support areas
- Operating outside safe operating limits accepted
- Varying shift operating practices tolerated

Procedures for Operation and Maintenance

- Failure to follow procedures tolerated
- Poor quality shift logs and/or inadequate shift turnover communication and rigor
- Chronic problems or inconsistencies with work permits

Asset Integrity and Reliability

- Bypassed alarms and safety systems--operation continues when safeguards known to be impaired
- High frequency of leaks
- Temporary or substandard repairs prevalent

Analyzing Risk and Managing Change

- Instruments bypassed w/o adequate MOC
- Failures to recognize operational deviations and initiate MOC reviews
- Evidence that temporary changes have been made permanent

Learning from Experience

- Frequent releases or leaks, small fires, and other substandard conditions have become the "norm" and are accepted as tolerable events
- Incident investigations not always being done or superficial with root cause not determined
- Symptoms or root causes being repeatedly found in incident investigations
- Repeat findings from previous audits

Source: Adapted from CCPS Concept Book concerning "Recognizing Catastrophic Incident Warning Signs in the Process Industries" (2012)

Insights from accidents in O&G industries

Common Root Causes of Major Accidents	Lessons Learned Across the Industry
❑ **Technical Failures**: Aging infrastructure, improper maintenance.	❑ Emphasis on **Safety Management Systems (SMS)**.
❑ **Human Factors**: Lack of training, fatigue, human error.	❑ Importance of **predictive maintenance** and inspections.
❑ **Organizational Issues**: Poor leadership, inadequate safety culture.	❑ **Leveraging technology** for hazard detection (e.g., AI, drones).
❑ **External Factors**: Natural disasters, cyber threats.	❑ **Continuous learning** from incident investigations.

Insights from accidents in O&G industries

Accident Prevention Strategies

•**Risk Assessment**: Identification and evaluation of hazards.

•**Process Hazard Analysis (PHA)**: Detailed analysis of potential risks.

•**Emergency Preparedness**: Regular drills, updated response plans.

•**Employee Training**: Comprehensive safety training and certification.

•**Technological Interventions**: IoT sensors, predictive analytics.

Adherence to Regulatory Framework and Standards

key safety regulations:

- **OSHA**: Occupational Safety and Health Administration, USA.
- **HSE**: Health and Safety Executive, UK.
- **API Standards**: American Petroleum Institute Guidelines.

Role of International Agencies (e.g., CCPS, NFPA) in promoting safety.

Indian regulatory Agency: PNGRB, PESO and OISD Guidelines, Safety Standards for Refineries & Petrochemical Installations.

Way Forward

- Be vigilant about the hazards of the materials and processes in your plant.
- Recognize “near miss” events to remind you of what could have gone wrong.
- Use incidents which occur in other facilities, such as the incidents reported in the Beacon, to remind you of the possibility of similar problems at your plant.
- Always operate within safe operating limits, and established operating procedures. When this isn’t possible, notify your supervision immediately.
- Use approved procedures for authorizing changes to established procedures, including thorough risk evaluation and approval by knowledgeable authorities.

Eliminating serious incidents requires constant attention to the potentially catastrophic results of hazardous activities.

CCPS : “Safety culture is how the organization behaves when no one is watching.” While management has a key leadership role in establishing a good safety culture in an organization, everybody must contribute.

Be Prepared!

- Participate in emergency response and "table top" drills so you are better prepared!

Passengers and crew evacuating US Air Flight 1549 following emergency water landing in the Hudson River in New York City (15 Jan. 2009)

Thank You