तेल उद्योग सुरक्षा निदेशालय
Oil Industry Safety Directorate
ISO 9001:2015 certified

सुरक्षा संवाद
Suraksha Samwad

An opportunity to learn from mistakes....

Disclaimer

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Sh. Vivek Prakash Singh
Joint Director, OISD

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Sh. Vivek Prakash Singh joined OISD in 2017 as Joint Director (Process & engineering). He has acquired Bachelor of Engineering (Honours) in Mechanical Engineering degree from REC, REWA (MP) under Rajiv Gandhi Proudyogiki Vishwavidyalaya, (MP).

He joined Indian oil corporation limited in 2006 and was posted at Panipat Naphtha Cracker project, the very first petrochemical venture of IOCL wherein he was involved in successful project execution, commissioning and maintenance of various petrochemical units like Mono Ethylene Glycol (MEG), Polypropylene and Butene-1 units.

He has 11 years' experience of project execution, pre- commissioning/commissioning, Maintenance planning & shutdown execution in Panipat Naphtha Cracker plant of Indian Oil Corporation Limited.

He has been continuously sharing knowledge/ lectures in various OISD workshops/ seminars

FIRE & EXPLOSION INCIDENT

IN

PETROCHEMICAL UNIT

- A Case Study to Ponder

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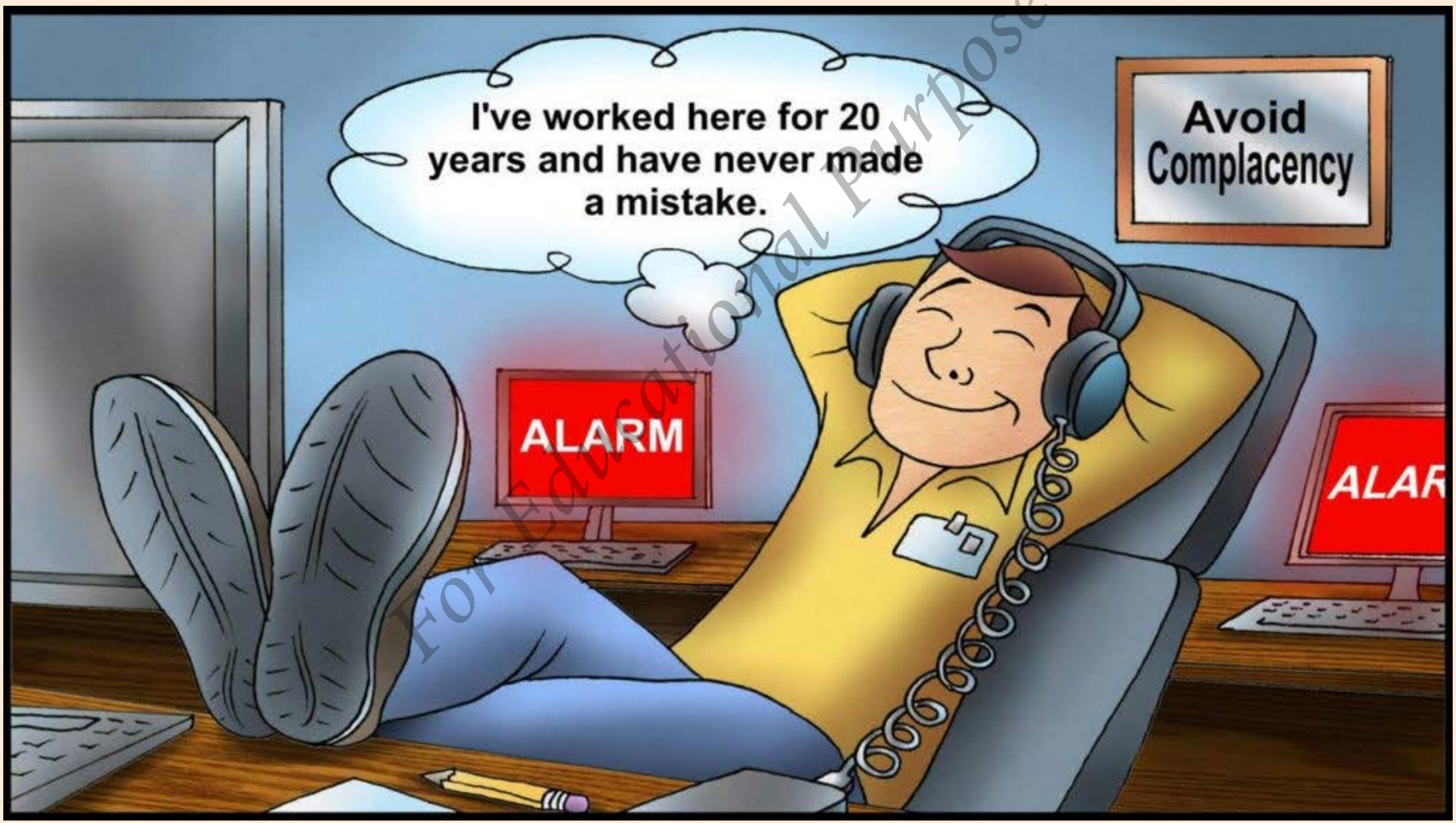

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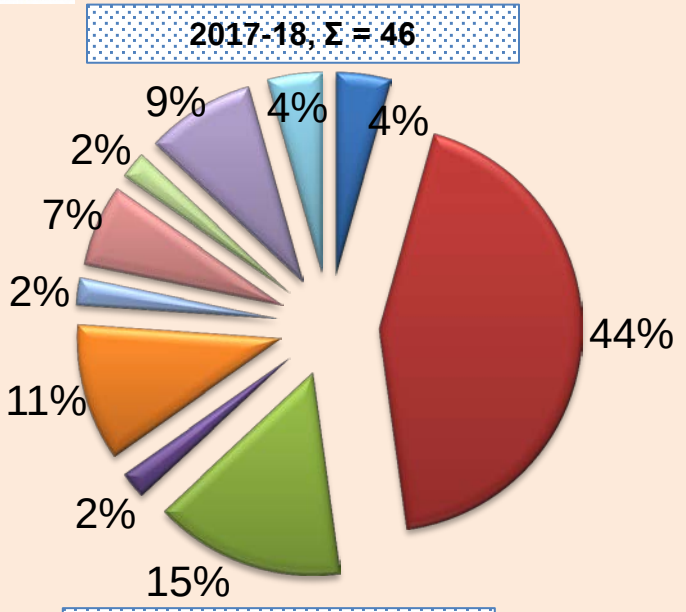
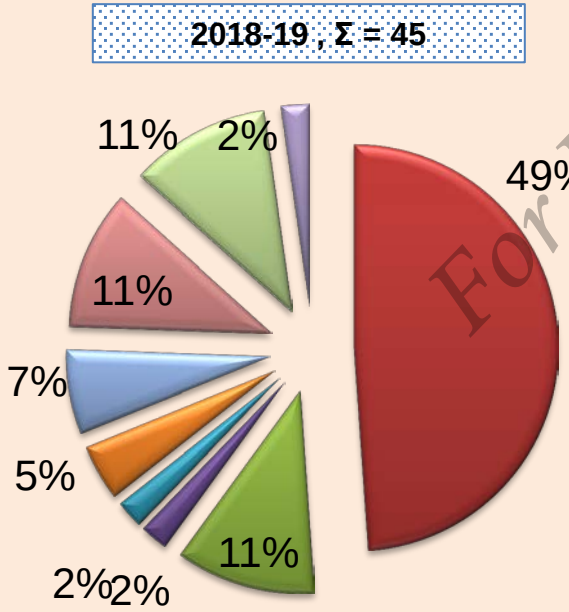
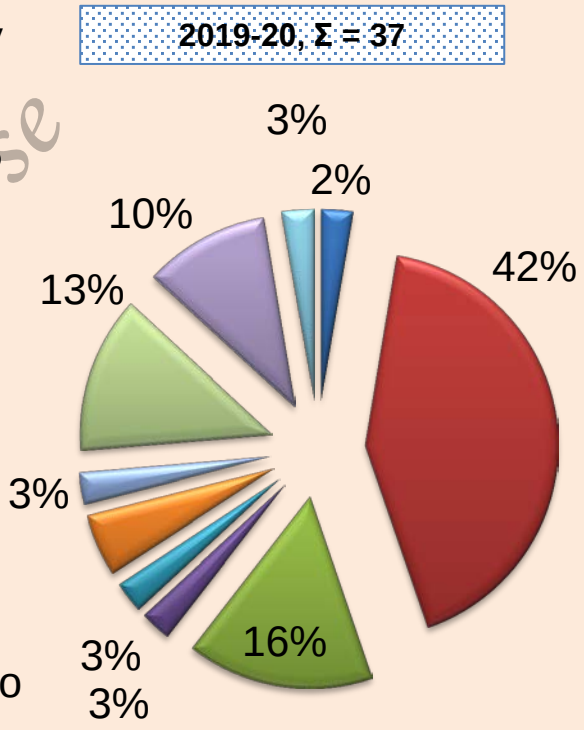
INCIDENTS – ROOT CAUSE ANALYSIS





- Design deficiency
- Disregard to SOP
- Equipment failure
- Inadequate job knowledge
- Negligent Driving
- Non compliance to PPE/fall & slip
- Others(e.g. Road Accidents, Crane Hydra etc)
- Pilferage/miscreant activity/others
- Poor maintenance & Inspection



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So What happened in that petrochemical incident?

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BRIEF OF INCIDENT

Location : *LLDPE / HDPE (SWING) UNIT*

Time of Incident : *About 12.30 Hrs.*

Incident :

- The LLDPE/HDPE (SWING) Unit is used for production of **Linear low density / High density Polyethylene polymer**.
- Catalyst building houses Catalyst/co-catalyst & deactivators feeding pumps for transferring the Cyclohexane & Catalyst /Co- catalyst batch to Reactor.
- At about 12:30 Hrs. on 22nd January 2018, Flash fire and explosion took place inside the catalyst building due to accidental release of **Cyclohexane & Tri Ethyl Aluminium** (TEAL) mixture.
- This had apparently occurred during an attempt to rectify the stuck open isolation ball valve installed downstream of TEAL Mix Tank V-111.

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BRIEF OF INCIDENT

- TEAL being pyrophoric in nature caused flash fire & explosion.
- Four employees & one contract worker working inside building came in contact with fire and blast.
- Subsequently, 02 fatalities occurred and other 03 persons got burn injuries.



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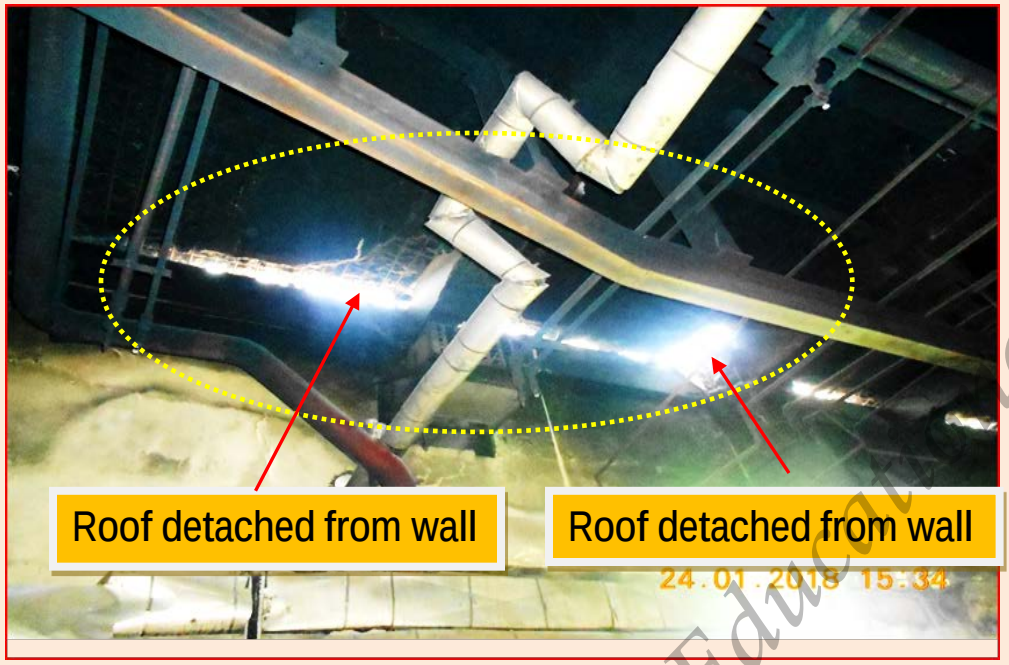
PICTURES OF INCIDENT



Damaged roof of Catalyst building



Damaged roof of Catalyst building- Top View

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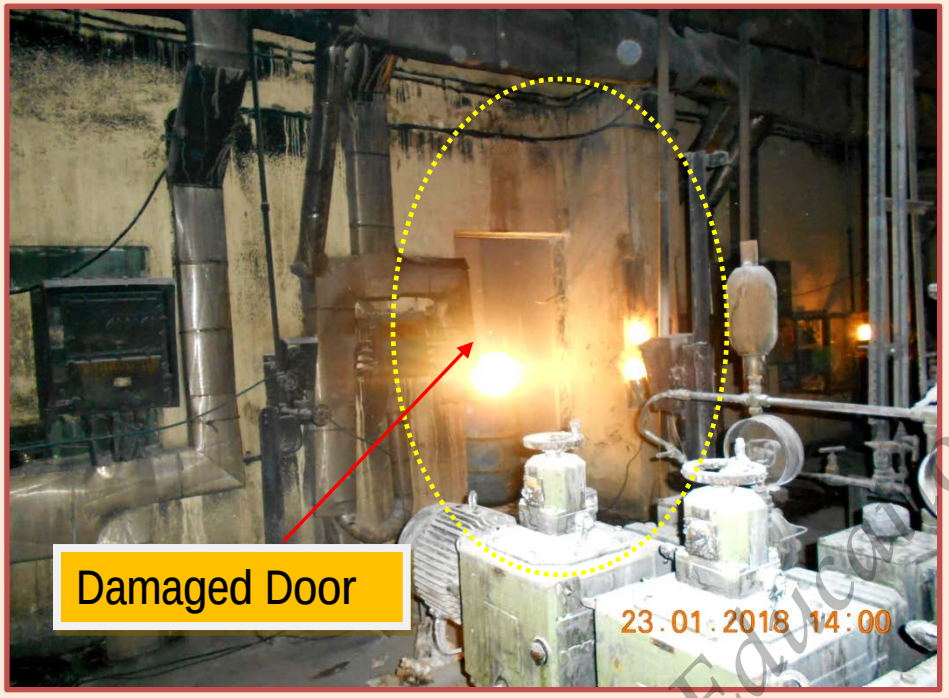
PICTURES OF INCIDENT



Middle door of building blown out



Insulation damaged due to Fire

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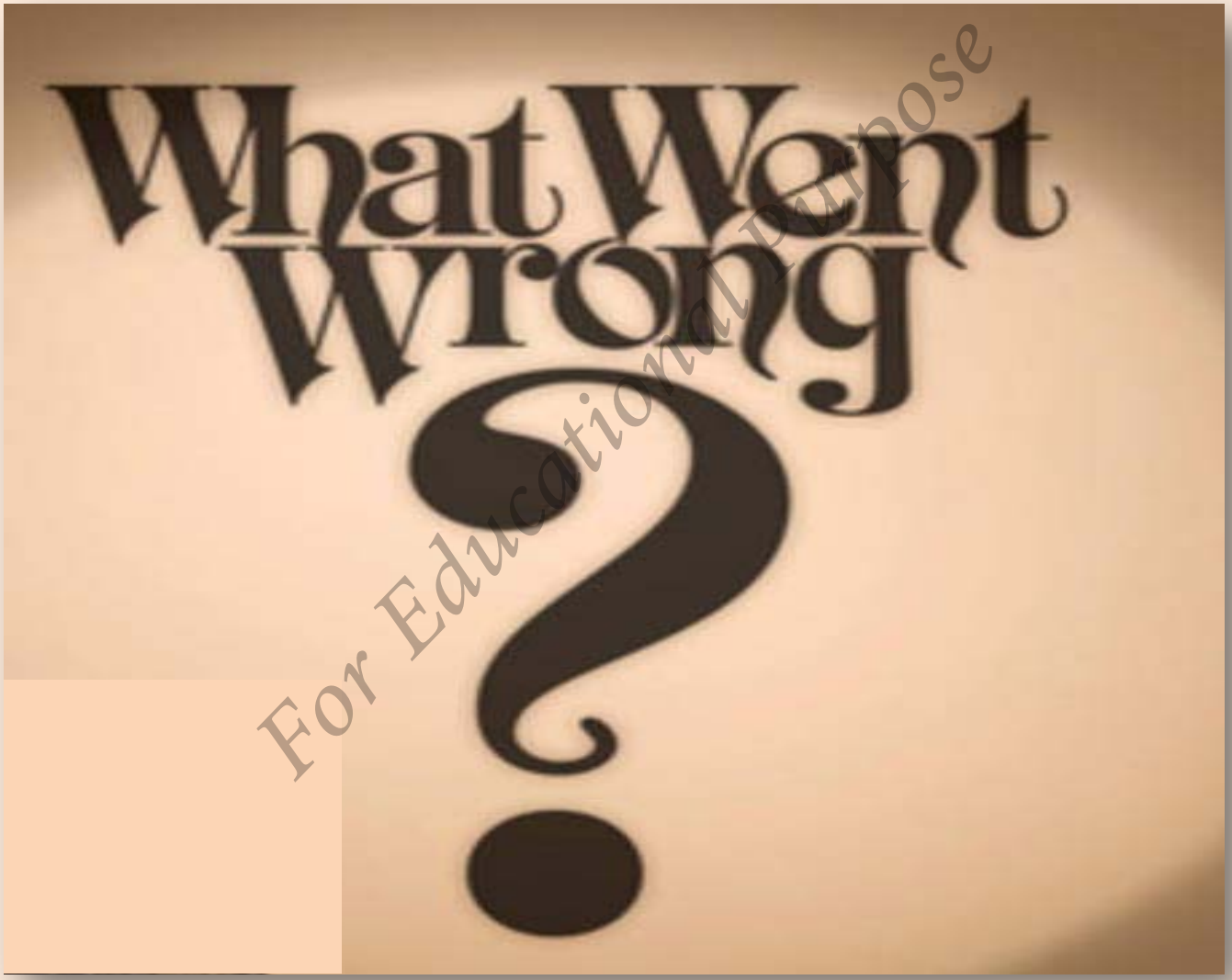

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BRIEF PROCESS DESCRIPTION

Polyethylene process unit is divided in 04 sections :

- ✓ Reaction Section,
- ✓ Recovery Section,
- ✓ Finishing Section &
- ✓ Utilities Section

- ➢ Catalyst/co-catalyst preparation and feeding is the part of Reaction section.

- ➢ Co-catalyst used:

  - ✓ CT – Triethyl Aluminium (TEAL),
  - ✓ CD – Diethyl Aluminium Chloride (DEAC),
  - ✓ CJ – Diethyl Aluminium Ethoxide (DEAL-E)

- ➢ CT, CD and CJ are pyrophoric in nature due to containing Aluminium Alkyl. Cyclohexane is used as solvent for making the co-catalyst batch.

- ➢ The catalysts and co-catalyst are received in cylinders or `ISO Containers' & then transferred by Nitrogen pressure to their respective mix tank.

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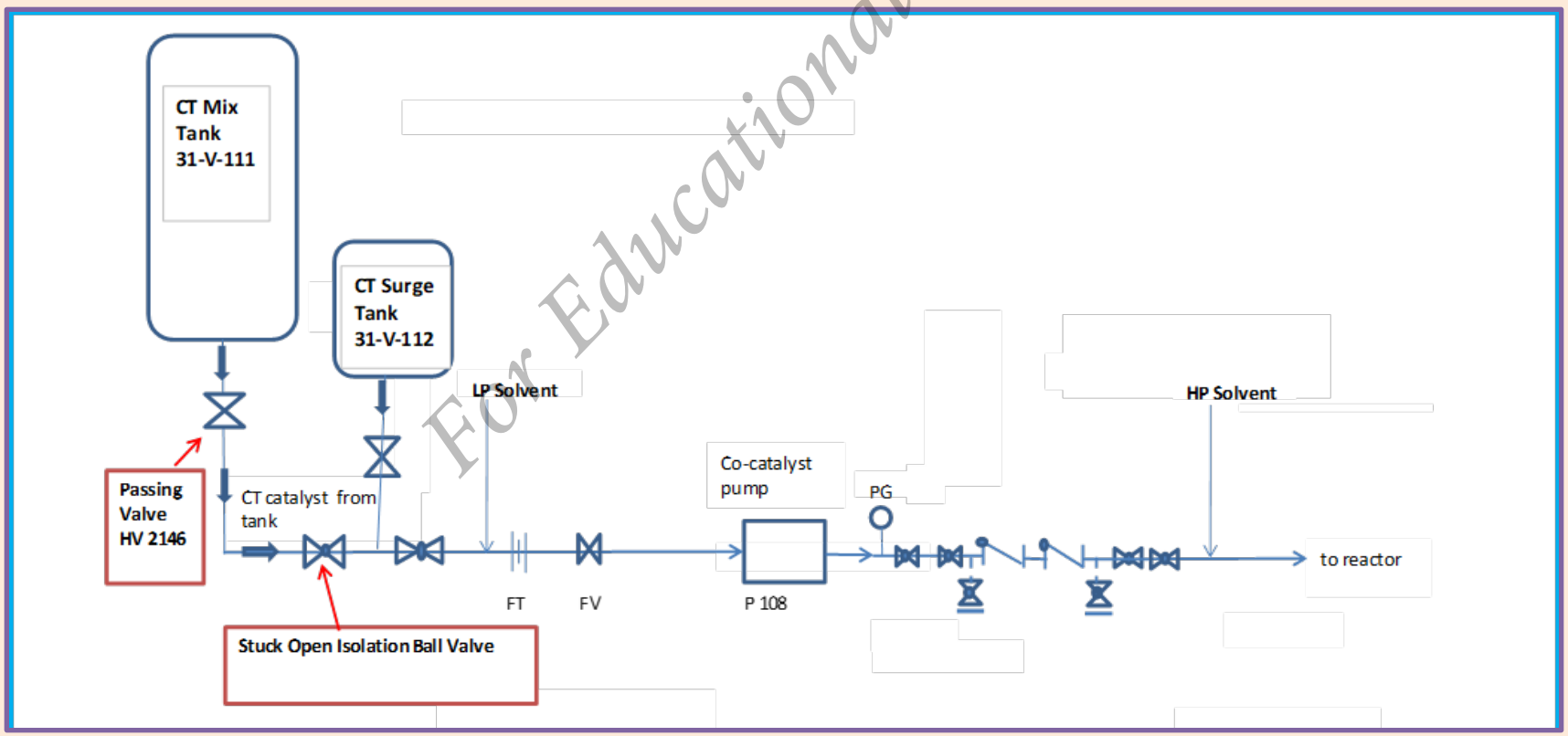
BRIEF PROCESS DESCRIPTION

- The CT (TEAL) batch prepared in the CT Mix Tank with 25 wt% concentration of TEAL with cyclohexane. CT Mix Tank & CT Surge tank are interconnected at such an elevation that Surge Tank shall be fully filled during feeding from CT Mix tank.
- During batch preparation, CT Mix Tank is isolated through Bottom valve HV 2146 & another downstream isolation ball valve and CT Surge tank is inline which is feeding the batch to TEAL Pump.



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SEQUENCE OF EVENTS

1. During operation, CT Mix tank downstream isolation valve got Jammed (Reported in DOR one month prior to incident).
2. During Batch Preparation, CT Mix Tank is isolated through HV 2146 & downstream isolation valve and CT surge tank is taken in line until batch is prepared. The CT mix tank bottom valve HV 2146 was also passing.

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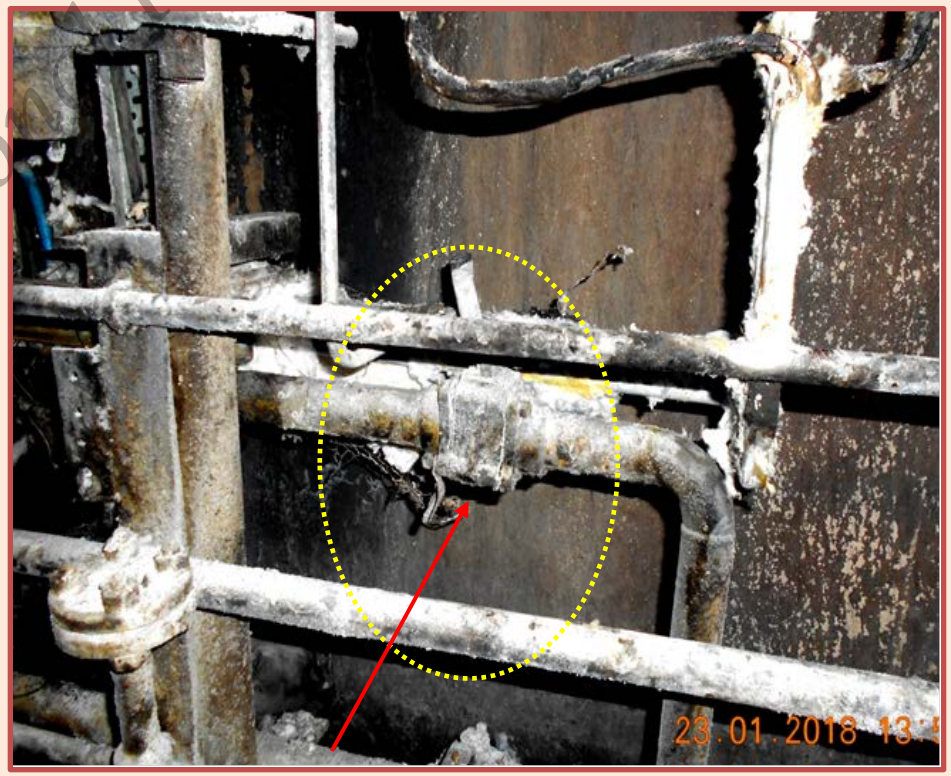
Passing valve HV 2146 of Mix Tank



Stuck Open isolation Valve (Jammed)

SEQUENCE OF EVENTS

3. Catalyst batch preparation was planned for the day Inspite of knowing the valve malfunction issues well in advance.

4. As per notification & work permit SAP record, neither notification nor permits were issued for any jobs related to CT pump or ball valve replacement job.

5. Also record of Job safety analysis related to ball valve replacement job was not available

6. Apparently attempt was made to rectify the jammed ball valve installed at downstream of already passing valve HV 2146.

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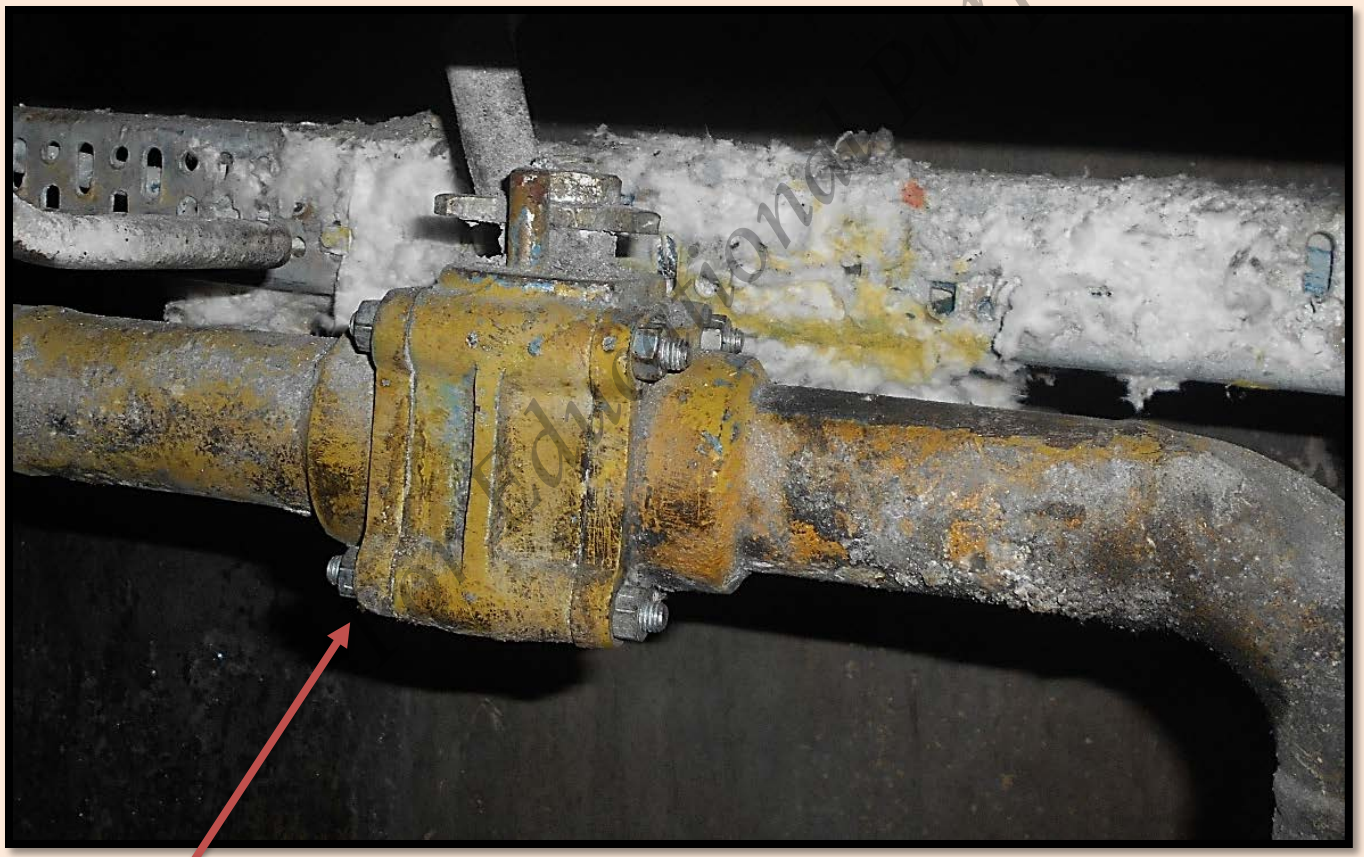
SEQUENCE OF EVENTS

7. During such attempt, leak occurred from the body of isolation ball valve resulting in accidental release of Cyclohexane & TEAL mixture from CT Mix Tank.



Stuck Open isolation Valve (Jammed)

SEQUENCE OF EVENTS

8. Due to Leakage, level of CT MIX tank dropped from 10.9% to 3.4% (DCS trend showed) along with pressure drop (Corroborating leakage incidence)

9. Level of CT Surge tank also dropped from 93.5% to 84% (DCS trend) along with pressure drop.

10. This accidental release of Cyclohexane & TEAL caused flash fire as TEAL is a Pyrophoric substance.

11. Due to presence of Cyclohexane Vapour cloud in the area, this flash fire resulted into explosion.

12. Further, Automatic activation of fire water sprinkler system caused heavy explosion due to highly reactive nature of TEAL with Water.

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ROOT CAUSE OF INCIDENT

- ✓ During an attempt to rectify the jammed ball valve, TEAL leakage from valve body caused fire & subsequent explosion due to Cyclohexane Vapour cloud.
- ✓ The above said ball valve was installed at downstream of already passing CT Mix tank bottom valve HV 2146.
- ✓ Attending a jammed valve in spite of a passing upstream valve without proper work permit, SOP & Job safety analysis resulted in accidental release of Cyclohexane & TEAL mixture.

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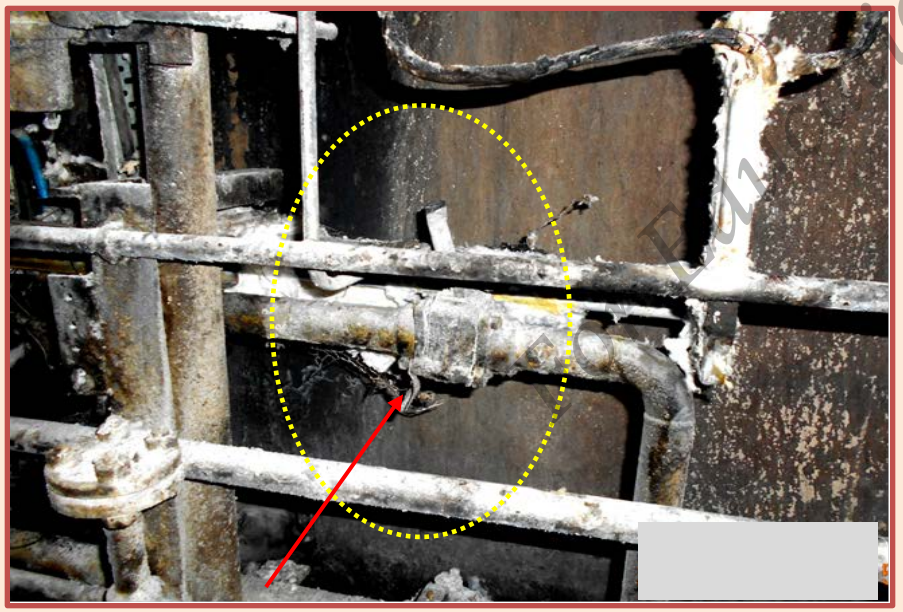

Stuck Open Valve (Jammed)



Passing valve HV 2146 of Mix Tank

MAJOR SHORTCOMINGS

- **Continuing operation with dysfunctional Valves:**

  Operation was allowed to continue with an upstream passing valve & downstream jammed ball valve. No approval for carrying out such operation was evident.

- **No Work permit & Job safety analysis for Valve rectification job:**

  Neither notification nor permits were issued for any jobs inside catalyst building. Also record of Job safety analysis related to ball valve replacement job was not available. SOP not followed for CT mix tank flushing.

- **Valve Passing issue not discussed in Sectional Safety Committee Meeting:**

  Being a very critical issue, the valve passing problem was not documented in the minutes of sectional safety committee meeting.

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MAJOR SHORTCOMINGS

- **Provision of Water sprinkler inside building not reviewed during design /construction stage or during HAZOP:**

  Inside catalyst building, Automatic Fire water sprinkler system has been provided. But TEAL reacts violently in contact with water. This hazard was not analyzed during construction stage or during HAZOP study.

- **QRA and ERDMP did not address TEAL fire hazard-**

  QRA (Quantitative Risk Analysis) & ERDMP (Emergency Response & Disaster Management Plan) don't cover the risk scenario of fire/explosion due to leakage / release of TEAL & Cyclohexane.

- **Gas detector not installed near pump area despite Licensor's safety guidelines-**

  No Hydrocarbon Detectors have been installed nearby any pumps inside the catalyst building.

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RECOMMENDATIONS

- Cyclohexane being a light Hydrocarbon, Gas Detectors should be installed near pump area inside catalyst building .

- In view of TEAL having explosive reaction of water, fire water sprinkler system inside catalyst building must be reviewed on the basis of Teal concentration. DCP extinguishers should be used for TEAL fire.

- Requirement of housing catalysts/co-catalysts pumps inside blast resistant building may be reviewed in consultation with process technology licensor & any reputed engineering consultant.

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RECOMMENDATIONS

- Enforcement of Work permit & job safety analysis (JSA) system implementation shall be strengthened.

- ERDMP should be updated with all risk scenario envisaged in fresh QRA study. TEAL fire hazard should be covered in ERDMP.

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THANK YOU

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