CASE STUDY

OISD/CS/2024-25/P&E/12 Dt.:15/10/2024

INTRODUCTION

Title: Explosion in furnace.

Location: Process (Crude Distillation) unit in refinery.

Loss/ Outcome: Damage of equipment, property, unit outage & production loss.

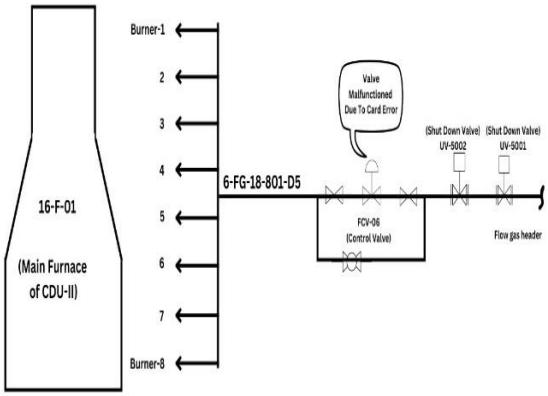
BRIEF OF INCIDENT:

Unit had resumed operation after M&I (Maintenance and Inspection) shutdown of 22 days. Startup and feed cut was done around 6 days before the incident that occurred at about the end of the night shift (early morning hours).

Certain areas of the refinery including the unit were inundated in around 1 to 2 feet water due to heavy rainfall since afternoon.

The unit was running at 450 m3/hr, at 73% of capacity. Around 2:30 hrs in the night shift, panel operator observed that the control valve supplying fuel gas to the Furnace along with a few other valves opening had clamped at the last opening. The shift-in-charge subsequently informed the concerned Instrument Manager for necessary corrective action. The instrument technician reached the instrument rack room at around 05:30 hrs. After analysing the problem, he reset the analogue control card of the controller. Consequently, the control valves connected to the card went into their fail-safe position inclusive of the Fuel Gas control valve, which closed completely ("Fail-Safe-Position") on its own, overwriting the value fed in DCS. Panel operator noticed the closed position of the fuel gas control valve after about 6-minutes.

The panel operator re-opened the fuel gas control valve manually from Distributed Control System (DCS) panel. Around 3 minutes later, explosion occurred in the furnace with momentary fire. Consequently, the shell of the furnace burst open.



This Case Study is based on the Investigation report done by OISD and published for information purpose only. This information should be evaluated to determine if it is applicable in your operations, to avoid recurrence of such incidents.

OBSERVATIONS / LAPSES

- The furnace shell had split from around 1 m about the burner floor to the furnace arch level. Furnace tubes were also uprooted from hangers. Some piping, electrical cables & trays, instrument & cables and insulation lining (blanket) inside furnace were damaged.
- Night shift panel operator was operating unit from 2019. He was in the unit as field operator since 2009. Panel operator assessment (before assuming panel charge) record was available, however no subsequent refresher training record were found.
- As per DCS trend, earlier in the morning shift of the day, the furnace excess oxygen reading was between 3 to 4%. However, after 15.20 hrs excess oxygen was in the range of 0.2 to 0.1 % till plant emergency shutdown. Furnace was balanced draft furnace. Although the excess oxygen could be adjusted from panel, action was neither taken by the evening, nor the night shift panel operator to increase combustion air flow. Normally the amount of excess air in the furnace is kept at 2-3% to ensure complete combustion.
- Due to unavailability of fuel gas (as other units, which were fuel gas generators, were under shutdown.), vaporised LPG was being used as fuel gas for furnace as per standard industrial practice. According to LPG lab report, 40.5% was propane and 58.6% butane, with rest consisting of heavier hydrocarbons.
- DCS analogue card failure alarm of fuel gas control valve appeared on instrument console as well as MCR operator console at 01:32 and 01:51 hrs in the night shift; however, it was not noticed.
- Any work permit related to the analogue control card rectification job could not be furnished. This was in violation of Cl. 7.3 of OISD-GDN-206 (Safe Work Practises) and organization's instrument SOP for "Online Replacement of Redundant DCS/PLC.
- The panel operator opened the control valve of fuel gas to furnace manually from panel, without following furnace start up procedure, i.e., purging for a defined duration, etc. This was also in deviation to the requirements of Cl. 9.2 of OISD-STD-111.
- Burner Management system (BMS) was not available in the furnace (16-F-01) as the furnace was an old one, commissioned in 1998. There was no "pilot on" indication available. Hence, the panel operator could not have ascertained that whether the flame was on in furnace or had extinguished when the fuel gas valves had closed.
- As per DCS record, FG supply control valve was opened from 0 to 50% (i.e., 2359 Kg/ hr) in about 3 mins. Considering the control valve flow characteristics, around 155 Kg LPG was supplied to furnace box.
- As per Sequence of Event (SOE) record (the alarm register of PLC), following interlocks related to the furnace (16-F-01) were bypassed since start of unit after M&I:
  - Lo-Lo Pilot Gas Pressure
  - Lo-Lo Fuel Gas Pressure
  - Hi-Hi Arch Pressure

  The bypass was done from DCS console without approval in non-compliance of approved Interlock Bypass procedure.
- Before explosion, Lo-Lo Fuel gas header pressure and Hi-Hi Arch pressure switch actuated. However, since the interlock was bypassed, shutdown was not triggered.
- At the time of incident furnace box temperature was above the LPG auto ignition temperature.
- Furnace stack damper physical opening could not be verified because of non-availability of stack positioner at grade level. This was a non-compliance of requirements of Cl. 5.4 of OISD-STD-111. Two numbers of OWS funnel were found within 10 meters of furnace. This was a non-compliance of requirements of Cl. 4.1 of OISD-STD-111.
- Organization had developed a detailed plan named "Managing Exigency During Heavy Rain" with responsibility matrix. As per Action plan, in case of cyclonic alert/ heavy rain/water flooding, various action had been identified like safe shutdown to be initiated if equipment submerged in

water or activate steam load shedding, etc. However, unit was running even after being flooded. No evidence of deliberation/ discussion/ meeting/ instruction to continue the plant operation was available.

CONCLUSION / ROOT CAUSE

The resetting of the fuel gas supply to furnace control valve analogue control card resulted in closure of the valve. Hence, the flame of the burners must have extinguished. Subsequently, when the panel operator opened the fuel gas controller manually, without following the procedure of purging the furnace before relighting it, the un-combusted gas got ignited on coming in contact with the already hot tubes and detonated.

RECOMMENDATIONS

- In case of flame failure/ failure of Fuel Gas/ Fuel Oil, furnace light up procedure i.e., box purging, pilot burner light up, main burner light up etc. shall be followed in line with Cl. 11.3 of OISD-STD-111.
- Lapses in compliance with the work permit system, interlock bypass procedure, SOP for "Managing Exigency During Heavy Rain" to be investigated and necessary corrective action to be taken for strict compliance in future.
- Installation of Burner Management system (BMS) in furnaces should be reviewed.
- Organization should reinforce the system of reporting of unsafe act emphasising acts of procedural bypasses, not following SOP, etc. followed by appropriate rectification measure and dissemination of learnings in endeavour to enhance the safety culture in line with OISD-GDN-206 cl no 5.1.4.
- Position of stack damper, while in operation shall be distinctly visible from ground as per clause no.5.4 of OISD-STD-111.
- A position based 'Three-Dimensional Competency Grid' including basic requirements, technical competencies and behavioral competencies to be developed to have a structured mechanism for tracking competency requirement, availability, interventions required and outcomes. Organization to ensure compliance of Cl. 7.2 of "Report of the Working Group on Safety in Indian Petroleum Sector". Structured training in functional safety shall be provided to all employees in line with Cl. 6.1.3 of OISD-STD-154.
- OWS open pits/ funnels within 15 M of furnace shall be relocated in line with Cl. 4.1 of OISD-STD-111.

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