

CASE STUDY

OISD/CS/2021-22/P&E/03

Dt.:09/11/2021

INTRODUCTION

Title: Fire incident in Crude Distillation Unit due to SR line leak.

Location: Refinery

Loss/ Outcome: Fire & Explosion, Unit outage & production loss, damage of equipment & property.

BRIEF OF INCIDENT:

The Fire incident took place in the afternoon hours during normal running of a Crude Distillation Unit (with integrated VDU) in a refinery. Fire was noticed in the pipe rack above the unit pump bay area adjacent to the Technical Structure and below the CDU column overhead circuit.

Immediately emergency shutdown of the unit was taken and refinery Fire service was mobilised. The fire was extinguished after about an hour and all-clear siren was activated. There was no injury to any of the operating or contract personnel; However, extensive equipment and property damage was observed due to the severity of the fire.

OBSERVATIONS / SHORTCOMINGS

- Subsequent to the incident, as a part of shutdown activity, flushing activity of the heavy oil circuits of VDU column was initiated. It was then, that heavy leakage of FLO (Flushing oil) was observed from one of the elbows in the discharge circuit of SR pump (Short Residue or VDU bottom residue), upstream of the Pre-Heat Exchangers.
- Insulation from the SR pipe section in and around the leakage point was removed. It was found that a hole of about 3" dia size had been bulged open on a 6" elbow. It was then concluded that source of fire was initiated from the heavy oil (SR) that had leaked from this big opening and got ignited due to auto ignition.



6" SR line ruptured hole in elbow - seen after removal of insulation



Ruptured hole after adjustment to facilitate temporary clamping and line purging

- The leaky section in the SR line was clamped to facilitate flushing out the bottom circuit of VDU column and subsequent shutdown activities prior to Maintenance & Inspection.

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- VDU column bottom liquid (SR) with operating temperature of about 350°C remains above its auto ignition temperature in the section from VDU column bottom upto the Pre Heat train and the leaky elbow was located in this section.
- After extinguishment of the fire, physical checking of the site showed that a number of pipeline sections, which had been under the fire envelope zone inside the plant area were in ruptured condition (e.g. fish mouth opening). CDU overhead Air Fin Cooler (AFC) fan blades (aluminium) and motors were damaged.
- During the fire fighting operation, sprinklers of CDU Overhead Reflux drum and Stabilizer Reflux drum could be opened only after some time as the operating valves were within the fire affected area and were difficult to approach.
- Both CDU & VDU column height were more than 45 meter and these columns were not provided Water spray rings.
- Fire proofing was not provided for the AFCs support structural.

Analysis of the damaged / leaky elbow of SR circuit

- Thickness of the failed elbow on SR circuit was found in the range of 1.8 mm (near hole) to 4.6 mm. Significant thickness loss was noted w.r.t. the previous thickness (6.0 to 7.8 mm) measured in last unit M&I (Four years earlier). Metallurgy of the elbow as per Positive material identification (PMI) was noted as Carbon Steel (CS).
- During the previous unit M&I, 100% PMI was carried out for the entire SR circuit. Two (02) nos. of adjacent elbows on the SR pump discharge line were identified as CS instead of Alloy steel (P5 metallurgy), which was required as per design. The said two elbows were marked on the isometric drawing for replacement with P5 Alloy steel material as one of the shutdown activities.
- However, while transferring the markings from the isometric onto another drawing attached with the Inspection Work Request, a different set of adjacent elbows (2 nos.) were inadvertently marked for replacement. This resulted in replacement of already existing P5 metallurgy elbows with new P5 elbows, while the CS elbows to be replaced, apparently remained intact as before. One of these CS elbows failed to cause the subject incident.

REASONS OF FAILURE / ROOT CAUSE

- The API-RP-571 (Corrosion and Materials) indicates that vacuum distillation plants/ circuits in a refinery are vulnerable to naphthenic acid corrosion (NAC) and sulphidic corrosion (SC) due to high Total Acid Number (TAN) and high operating temperature in the produced fractions. NAC is mostly localised corrosion predominantly in location of change in flow direction or high turbulence. Keeping these aspects under consideration, alloy steel (P5) metallurgy was recommended for the SR circuit.
- Due to presence of CS metallurgy, accelerated localised corrosion/ erosion must have occurred resulting in thinning and failure of the subject CS elbow.

Similar incidents are reported in the past in other refineries also.

CONCLUSION

- From the above analysis, it is concluded that the immediate cause of the fire was due to the SR leaking out from the failed CS elbow, which resulted in instantaneous fire due to the fluid temperature being above its auto ignition temperature.

RECOMMENDATIONS

- Industry needs to review and strengthen the system of PMI checks at the project execution stage itself to eliminate lapses of metallurgical mismatch.
- A robust system shall be implemented for quality checks at different stages of job planning & execution during normal as well as TA activities related to piping works to prevent error in marking of drawing (in Maintenance/ Inspection work list) offered to executing agencies. PMI shall be done to re-confirm before and after site execution

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- Industry to create integrity operating windows (IOW) in the critical high temperature circuits and introduce a system of periodic monitoring of metal integrity in line with API RP 584.
- Air Fin Coolers (AFCs) in hydrocarbon service located above pipe racks/ elevated location shall be provided with water sprinkler system in line with OISD-STD-116 clause no. 4.2.5.
- Columns having height more than 45 meter shall be provided with water spray rings in line with OISD-STD-116 clause no. 4.2.5.
- To review the gaps in fire proofing of AFC supports and other structures in line with OISD-STD-164, Clause 5.3.2, 5.3.3 and implement necessary measures.
- Automatic shutdown valve (ROSOV) shall be provided at CDU and VDU column bottom outlets for column isolation in line with OISD-STD-152 clause no. 4.2.4.2.
