OIL INDUSTRY SAFETY DIRECTORATE
NOIDA

Case Study: Fire Incident at HSD Fixed Roof Tank in an Indian Refinery by lightning strike

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THE INCIDENT:

- A fire broke out in HSD fixed roof Tank in the month of October, 2017 when there was sudden change in weather condition to thunderstorm and heavy lightning.
- Initial fire fighting was carried out by outsourced operating group having limited experience/ exposure of Oil & Gas industry. Support from mutual-aid partners also arrived at site at later stage and assisted in fire fighting activities.
- The fire continued for almost four days.

INCIDENT OBSERVATIONS:

- There was a fire on the top of HSD fixed roof Tank which was surrounded by 2 nos. of HSD tanks and 1 No. of FO tank.
- Fire fighting activities carried out in HSD Tank-A (on fire) along with cooling of adjacent Tanks.
- It was observed that fire water header pressure was about 3.5 - 4.5 kg/cm2g resulting in ineffective fire fighting initially which was subsequently increased to 6-6.5 kg/cm2g
- There was no Disaster Control Room set-up at incident site.
- As the HSD Tank-A was on full surface fire, therefore controlled burning was allowed.

- Product evacuation from Tank-A and adjacent tanks was carried out through pipeline transfer to nearby Refineries. Simultaneously, adjacent tanks were kept under water cooling through sprinkler system.
- There was fixed foam system having 4 Nos. foam storage vessel of capacity 7500 litre each), however, upstream side inlet fire water 12 inch valve was in closed condition.
- The water sprinkler system of adjacent tanks were working but having some flange leakages. Some of the sprinkler spray nozzles were also chocked.
- The water sprinkler system of one HSD tank close to the tank-A on fire was having no leakage from flanges and spray nozzles were working satisfactorily.
- Foam containers were brought from various sources to the incident site and the foam layer was made in adjacent HSD tanks, by injecting foam through foam pourer, for blanketing purpose.
- It was observed that CCTV was working and showing the picture of fire in HSD Tank-A in C/R. However, fire incident video couldn't be retrieved as connected hard disk was faulty.
- It was observed that Tank manifold isolation valve was inside the dyke, so positive isolation couldn't be achieved.
- Due to the prolonged fire, Tank-A roof collapsed and subsequently shell got fragmented but bottom two courses of shell was more or less intact.

- The intensity of fire was reduced on 3rd night at around 2200 hrs. However, on 4th day morning again intensity of flame increased. Finally, after closing the Inlet/ Outlet

isolation valves of other two adjacent tanks including bypass in pump house, the intensity of fire got reduced and finally fire put off at 0015 hrs on 5th day.

REASONS OF FAILURE/ ROOT CAUSE:

- Tank-A was commissioned in 1988, having diameter of 48 m, capacity of 32000 KL, fixed roof type, storing class 'B' petroleum product.
- Original roof was having 8 mm plate thick and during 1st M&I in 1997, 4 Nos. of pitted/ perforated/ cracked plates were replaced with 8 mm thick plate. During 2nd M&I in 2007, complete roof was replaced with 6 mm thick plate due to roof thinning & perforation at several locations. Replacement with 6 mm thick plate instead of 8mm is not known.
- Subsequently, external visual inspection was carried out in 2014 and 2017. During these inspections, roof thickness measurement was not carried out though the requirement is stipulated in OISD-STD-129. Acoustic Emission Testing (AET) was carried out in 2017 to determine condition of tank bottom plate and based on the AET results only, M&I of the Tank-A was extended to next year. Shell and roof integrity was ignored before giving extension.
- Considering the past corrosion rate history of roof plates it can be concluded that the tank- A roof plates were thinned out / pitted.
- The root cause of Tank-A fire was that roof plate thickness must be less than 4.8 mm and got punctured due to lightning strike resulting in fire. As per OISD-GDN-180, the contents of metallic tanks used for the storage of flammable liquids are considered to be inherently self-protecting against lightning if roof has a minimum thickness of 4.8mm.

CONCLUSION:

- The roof plates were thinned out / pitted after 10 years of operation since 2nd M&I in 2007.
- Acoustic Emission Testing (AET) was carried out in 2017 to determine overall condition of tank bottom plate. Based on AET results only, M&I of the Tank-A was extended to next year, without assessing the condition of roof plates by thickness measurement even though past replacement history of this tank roof plates suggest that the corrosion rate was high.

- For Fixed roof storage tanks to be considered inherently self-protecting against lightning, the roof shall have minimum thickness of 4.8 mm (OISD-GDN-180 & NFPA 780).
- Heavy lightning strike generated high heat which punctured the thinned out/ pitted tank roof. As flammable hydrocarbon vapours were present inside the tank, it got ignited due to heat, resulting in fire on top of the Tank. It may be mentioned that average lightning strike delivers about 30 kA of electricity to ground within a few milliseconds. The peak amplitude of first return stroke of lightning current may reach up to 200 kA (API-RP-545). The lightning stroke can generate temperatures as high as 30000°K in the discharge channel (OISD-GDN-180).

MAJOR RECOMMENDATIONS:

1. During every external inspection of tanks roof thickness measurement shall be taken as per OISD-STD-129 (*Fixed roof storage tanks to be considered inherently self-protecting against lightning, the roof shall have minimum thickness of 4.8 mm)*
2. M&I of Tank shall be extended after complete integrity assessment of bottom, shell and roof plates.
3. Fire water pressure at the farthest point to be ensured 7 kg/cm^2 at all the time.
4. Tank manifold isolation valves should be located outside the dyke.
5. Outsourced operating staff at critical area to be avoided. If outsourced, the minimum qualification, experience in oil & gas industry shall be ensured.
6. Extensive Fire fighting training to be imparted to all operating personnel.
7. Standard Operating Procedure (SOP) for Foam Pourer operating system to be approved by competent authority.
8. Fire water sprinkler system and Foam pourer system to be checked periodically as per OISD-STD-116.