Rupture of Corroded Liquid Hydrocarbon Pipeline in a Refinery

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A. INTRODUCTION

At about 1320 hours during September, an incident of fire took place at one of the tank farm area of a Refinery. During the incident four contract personnel received severe burn injuries due to flash fire caused by sudden rupture of a 20" dia HSD line passing near by the tank farm area. All the injured persons were immediately shifted to a major hospital after initial first aid treatment at Refinery Occupational Health Centre. Three of these personnel later succumbed to their injuries.

B. THE INCIDENT

- In excluded class storage tank farm of a Refinery a fire took place at about 1320 hours. The fire was caused due to sudden rupture of 20" HSD pipeline running adjacent to the said tank farm. As per eyewitness accounts, heavy vibration coupled with hammering sound was observed prior to the rupture of the pipeline. The product jet from the ruptured portion of the pipeline found ignition source inside a tank (located at a distance of about 45 meters from the rupture pipeline location) where hot work activities related to M&I of the tank were in progress at the time of the incident. The roof of this cone roof tank was earlier removed by cutting during the ongoing M&I of the tank.

Four contract personnel working inside the tank got drenched with this sudden spray of liquid and were caught in resultant flash fire. All the personnel received severe burn injuries and were immediately shifted to a hospital after initial first aid treatment at the Refinery Occupational Health Centre. Three of the personnel succumbed to their injury subsequently.

The fire which had spread in the entire tank farm area was brought under control subsequently.

C. OBSERVATIONS

- The Refinery had a 20" dia. pipeline connecting the product tank farm with one of the tanks used as intermediate storage tank. This pipeline is also used for HSD tanker loading purpose at jetty/pipeline transfer to the marketing tanks. There are three pump houses connected with this line for multiple use of transferring/receiving the product to/from various sources.
- All the activities related to receiving to/from the line such as start/stop of pumps, opening/closing valves, pump start/stop timings etc. are

manual and are carried out on as when required basis and records are maintained by field operators in respective log books of each area.

- Tank used for storing intermediate product is not equipped with any online level measurement provision since last seven to eight years. In the absence of any online level measuring device close monitoring of level in this external floating roof tank particularly while receiving the product could be an area of concern. During the investigation, the team could observe one incident wherein this floating roof tank level exceeded its maximum design filling height. Such type of level overshoot although marginal could have been avoided if tank had been provided with online level measurement gauge.
- Various modifications (additions/deletions etc.) in the pipeline routing which were carried out in the past have not been captured as these changes/modifications seems to have been carried out without following the MoC process as per OISD 178. For example, it was informed that the pipeline section up to the intermediate tank used to get pressurized during product transfer to Marketing/pipeline transfer activities and to overcome the same additional isolation valves at the common manifold location were incorporated to address the problem. No MoC records were available for the modification.
- Complete replacement of this pipeline of approximately 250 meters length (from product pump house to the intermediate tank) was advised by the Inspection section of the Refinery long back. However, during the investigation, it was noted that there was one clamp in the pipeline section at a location near to east side of the intermediate tank.
- On-stream inspection of the offsite area pipelines is not carried out by the Inspection section of the Refinery as stipulated in clause 8.0 of OISD STD 130. Though the thickness measurement readings have been taken in between but the observations have not been documented in the format as provided in the standard. Also the thickness data analysis to arrive at remaining life assessment of these pipelines has not been carried out.
- The replacement of the pipeline was started around six months back and till the date of incident, three sections of pipeline have been replaced. The last section was replaced just four days prior to the incident. There is a section of the pipeline (around 80 meters) which is still pending for replacement. The portion where the rupture occurred on the date of incident falls under the same section which is yet to be replaced.
- Replacement of the entire pipeline as recommended in the inspection report could have been taken up along with Major Refinery Turnaround which was undertaken most recently.
- Severe external pitting and corrosion is observed in the ruptured section of the pipeline. Random measurement of thickness at the ruptured section taken reveals that minimum thickness at the ruptured section is

3.6 mm against the original thickness of pipeline which is 6.35 mm. But considering the severe external corrosion and deep pitting on the pipe section it can be implied that the thickness of the pipeline at the rupture location might have gone below the measured thickness of 3.6 mm. (Please see the following photograph showing severe external corrosion and deep pitting on the pipeline). It is clear that failure at this severely corroded section happened due to sudden pressure surge on the date of incident. The cause of severe external corrosion on this section of the pipeline is mainly attributed to spray of fine mist from the cooling tower and severe corrosive atmosphere of this coastal Refinery.

- As per eyewitness accounts, there was heavy vibration in the line coupled with knocking sound prior to its rupture. Foundation of the concrete sleeper for supporting the pipeline section near the ruptured location has developed cracks. Also the pipeline guide supports are observed to have been damaged at some locations (see enclosed photograph) due to heavy vibrations in the pipeline. Based on literature available, such type of phenomenon occurs due to sudden pressure surge in the pipeline also referred as "Water Hammer" in liquid pipelines. One of the prime reasons to trigger such events (water hammer or surge) is the sudden start/stop of the pump or abrupt closure of valve in the pipeline circuit.
- Heavy vibrations coupled with knocking sound observed in the pipeline prior to the incident could be due to thermal expansion or/and two phase gas liquid flow in the pipeline. It could not be confirmed as to whether such phenomenon had occurred earlier also during the normal operation of the plant any time in the past. Experience has shown that there are instances where the operators concerned have tried to trouble shoot such abnormal vibrations/knocking sound in pipelines by starting the pump. Such decisions are taken sometimes in an isolated manner without the knowledge of concerned supervisors. The possibility of such action in this case also cannot be completely ruled out.
- After careful analysis of intermediate tank level manual dip details for the last three days prior to the incident, it is established that this tank lost about 76 Kl of product in the morning shift of the date of incident. It was confirmed that there was an attempt to transfer the product from this intermediate tank to some other tank in the Refinery by operating the pump. The fact that spray of product in the tank farm was observed up to a distance of 50 meters radius and this sustained flow of jet continued for a period of 5-10 minutes, further corroborates the claim that pump was in operation at the time of the incident.
- Heavy accumulation of black oil is observed in the entire tank farm area. On the day of the event this heavy accumulation of oil resulted in spread of fire in the tank farm area in all directions.

E. ROOT CAUSE OF THE INCIDENT

- Huge pressure surge in the pipeline occurred due to sudden start / stop operation of the pump or sudden valve operation that led to failure of the corroded pipeline.
- Severe external corrosion and deep pitting on the pipeline has led to substantial thickness reduction of the pipeline section which ultimately resulted in failure. With such condition the pipeline should not have been operated upon or should have been de-rated till the replacement was undertaken.

F. RECOMMENDATIONS AND LEARNINGS FROM THE INCIDENT

- Pipeline with such severe external corrosion should not be operated without implementing critical inspection recommendation for replacement.
- Operations in OM&S area particularly involving long distance transfer of products/intermediates from one pump house to other tank farm must be closely supervised to always ensure proper line-up and to avoid any unsafe operation.
- Carry out a detailed structural analysis of the entire pipeline route and provide adequate additional supports wherever required to ensure its mechanical integrity.
- Carry out detailed metallurgical/chemical analysis of the ruptured section of pipeline as learning for the future to avoid recurrence of similar failures elsewhere.
- Level instrumentation of hydrocarbon storage tanks should always be as per clause 4.2.12 (i) of OISD-STD-152. All the tanks should be provided with minimum two numbers of level instruments working on different principles of measurement.
- Possibility of providing pump start/stop indication with recording in DCS system of the OM&S control room should be considered for enhancing overall operational integrity in the offsite areas.
- Overall housekeeping of the tank farm area needs drastic improvement.
- All the modifications in the plant should be carried out following MoC procedure as per OISD 178. Modifications done in the pipeline routing in the past did not follow the MOC procedure.
- Pipeline inspection both On-stream and comprehensive should be carried out as per frequencies specified in the Clause 7.0 of OISD STD 130. Also the documents for these inspections to be maintained as per procedure at Clause 8.0 of OISD STD 130.
- Requirement of provisions for TSVs in critical offsite pipelines to avoid pressure surge may be studied.