

LPG Leakage from bulk TT during unloading

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1.0 The Incident

- 1.1 At around 1630 hrs. an LPG Bulk TT – loaded with 17.85 MT of LPG was placed for decantation at an LPG BP.
- 1.2 The TT driver reportedly placed the said TT in one of the bays viz. Bay #15 – still under construction and yet to be commissioned – of the TLD 1 and lined it up for decantation by connecting the quick release type unloading coupling (both the male and female part) all by himself. On being advised that the said bay was not yet commissioned, he reportedly tried to take the TT away without decoupling the unloading arm.
- 1.3 In this process the liquid and the vapour line nozzles of the TT were sheared off the bullet.
- 1.4 Entire TT content leaked out through the liquid outlet line at the bottom of the bullet. Major disaster was averted by timely action by the Plant Personnel (dispersions and cooling by sprinklers) and favourable wind direction which blew the vapour cloud away from populate side of the plant to vacant marshlands.

2.0 The LPG BP

- 2.1 Commissioned in early 1994 the LPG BP has present installed capacity of 132 TMTPA (3x24 gun carousal). The manpower strength is – 15 officers, 05 WCWs and 52 BCWs. Additionally 127 contractor workers are deployed in loading/unloading, handling & housekeeping and security.
- 2.2 The plant is spread over 79 acres of which 35 acres is licensed area.
- 2.3 The plant has 1250 MT of Bulk LPG storage in 10 A/G bullets.
- 2.4 The plant receives LPG exclusively through bulk TTs.
- 2.5 Bulk TT decantation is performed in two Tank Lorry decantation set ups – TLD 1 & 2 with 6 operating bays. Presently 5 bays are operating with the 6th bay blocked by fire screen set up in connection with construction of 2 more bays in each of them.

3.0 The Investigation Methodology

- 3.1 The incident site was visited by OISD team along with Loc I/Ch and other senior officials from OMC's controlling office.
- 3.2 Personal interaction was done by OISD team with Loc I/Ch; the officer concerned with shift operation plus officer & workmen of TLD section of B shift, 10.09.12.
- 3.3 All relevant documents were collected for subsequent study, corroboration and analysis with respect to the incident.
- 3.4 Site photographs as on dates of investigation were taken.

4.0 The submission of Loc I/Ch of the LPG BP

- 4.1 The bay no.15 of TLD 1 was yet to be commissioned as on the date of incident.
- 4.2 The bulk TT decantation procedure at the location is as follows:
 - 4.2.1 The bulk TTs are taken in bunches of 5 & 6 (matching the bay availability of TLD 1 & 2) at the beginning of the shift.
 - 4.2.2 Each TT takes about 8 hours for decantation. Therefore, in each shift a batch of maximum 11 TTs are decanted matching the bay availability in TLD 1 & 2 put together.
 - 4.2.3 The TTs at the main entry gate are checked by the gate security.

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- 4.2.4 After this check, the TTs proceed to TLD in the battery limit area through the security controlled barrier gate.
 - 4.2.5 As per practice in the plant, TTs in bunch of 5 proceed to TLD1 and TTs in bunch of 6 proceed to TLD 2.
 - 4.2.6 At the TLD, the charge-man assigned to the section hands over the male unloading couplings to the driver for fixing to TT liquid and vapour line. The charge-man does the interlocking of male/female coupling and starts the unloading process after ensuring requisite safety checks and taking over custody of TT ignition key.
 - 4.3 In case of this incident, the driver of the concerned TT placed it in bay no.15 of TLD 1 on his own. He also lined up the necessary connections for unloading. Then he tried to drive the vehicle away without decoupling the connection.
 - 4.4 In this process, the vapour and liquid line of the TT sheared off from the tank shell. In the vapour line the EFCV was intact but in the liquid line the EFCV itself came out with its seat through shearing off the threaded EFCV housing. Therefore, the liquid line became through and the primary containment of the shell was lost.
 - 4.5 Consequently, the entire liquid leaked out.
 - 4.6 The plant management could hear the sound of the nozzle giving in and also could see the resultant vapour cloud.
 - 4.7 Immediately, the ESD button was pressed activating the siren & the sprinklers at TLD, closing ROVs of the vessels & the delivery headers.
 - 4.8 Further, the nozzles & monitors around the area were activated to disperse the accumulated vapour cloud.
 - 4.9 Civil fire brigade and police in addition to district authorities were informed in line with the plant DMP.
 - 4.10 Continuous monitoring of the gas concentration in the incident area was done through explosimeter. Reading was observed to be ZERO (% of LEL) after 25 minutes
 - 4.11 By 11.09.12 at 0900 hrs. successive explosimeter readings of the plant area and surrounding beyond plant boundary wall were observed to be ZERO.
 - 4.12 At 0930 hrs. on 11.9.12 plant operation was resumed.
 - 4.13 PESO issued a show cause notice to IOCL on 11.9.12 citing violations and on 12.09.12 issued order temporarily suspending Explosive license of the plant.
 - 4.14 Plant operation was suspended wef 12.09.12 and it was still under suspension as on the date of this investigation by OISD.
- 5.0 OISD Observation on site**
- 5.1 The plant operation was suspended.
 - 5.2 The private approach of the plant had LPG packed trucks parked all along on the left curb.
 - 5.3 The designated bulk and packed TT parking area/s were full.
 - 5.4 Partially unloaded LPG bulk TTs and partially loaded cylinders in packed trucks were parked inside the plant.
 - 5.5 The TT under reference was still parked in bay 15 of TLD 1.

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6.0 OISD Investigation

- 6.1 Duty roster of officers and workmen for B shift 10.09.12 was examined.
- 6.2 Bio-data of the concerned employees were examined.
- 6.3 Process study of Bulk TT unloading as practiced in the location was done
- 6.4 SOP for bulk TT unloading was studied.
- 6.5 The condition of the TT, broken piece of the TT manifold still attached to the loading arms and the EFCV of the liquid line which gave away on movement of the TT while still coupled to the loading arms was examined and photographs were taken.
- 6.6 Inspection of the bulk unloading facilities in TLD 1 including the bays under construction was done.
- 6.7 Inspection of the area surrounding TLD 1 was done.
- 6.8 Area surrounding the plant (beyond boundary wall) vis-à-vis the approved layout plan was surveyed from road level
- 6.9 Personal interaction with location in-charge, the concerned security supervisor, BCW, officers and workmen member of safety committee (in presence of location in-charge) was done.
- 6.10 On site demonstration of TT connection with loading arm by the concerned BCW and officer was conducted in presence of location in-charge and officers of KeSO LPG.
- 6.11 RA, HAZOP study, DMP, Fire drill record, fire engine operation register and MoM of Safety Committee meeting were examined.
- 6.12 Latest MDT inspection report was studied.
- 6.13 Movement history of the concerned bulk TT was checked. Bulk TT drawing was examined.
- 6.14 Statutory Licences of the plant were examined.
- 6.15 Hot work permits issued for the two bays under construction in TLD 1 were examined.
- 6.16 GMS log of TLD 1 pertaining to B shift was examined.

7.0 OISD Analysis

- 7.1 On over all analysis, it appears that a major disaster in this near miss incident was averted by a combination of the following factors:
 - 7.1.1 Favourable wind direction and speed.
 - 7.1.2 Timely and adequate action of the plant personnel in tackling the vapour cloud formation by ensuring safe & expeditious dispersion and eliminating any source of ignition within the plant.
 - 7.1.3 Presence of available and efficient fire fighting system within the plant.
 - 7.1.4 Lack of human population along the major part of the plant perimeter.
 - 7.1.5 Adequate buffer zone and inter-facility space available in the plant ensuring containment of vapour cloud within the plant prior to dispersion and minimising possibility of coming into contact of potential external ignition source.
- 7.2 From the roster, it was observed that three workmen are deployed for supervising TLD-1, TLD-2 and LPG pump house. Out of this three, one workman is for relieving leaving each

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of the rest two to look after TLD 1 & 2 plus LPG Pump House on rotation basis. Specific roles and responsibilities with respect to job allocation to each BCW do not exist.

7.3 The above deployment pattern inter-alia means :

- 7.3.1 The TLD 1 & 2 at the best of the times is manned by only one BCW. The layout of TLD 1 & 2 is such that clear line of sight from one to the other is not available. Therefore, the effectiveness of supervision is questionable.
- 7.3.2 Shared responsibility within a shift further weakens the individuals' accountability system.
- 7.3.3 The LPG pump house and the TLD sheds are separated by considerable distance. Therefore, during change over from one BCW to the other both the facilities can remain unattended.
- 7.3.4 Absence of concerned BCW from a particular work site increases the probability of bulk TT drivers over reaching their responsibility areas while ensuring fast turnaround of the bulk TT in unloading process – which, by design, at this location takes an entire shift i.e. 8 hours.
- 7.3.5 It may be worthwhile to note here that the TT under context was loaded on 30.08.12 and it could finally be placed for decantation only on 10.09.12 B shift i.e. after 11 working days. If the driver would have missed this decantation cycle, he would have been detained for 24 hours more (as decantation by B shift would have allowed the bulk TT to hit the road on 10.09.12 night itself otherwise the next earliest opportunity was 11.09.12 night as bulk TTs were being allowed to ply only during night time in the state, consequent to an LPG bulk TT BLEVE incident in the state). Therefore, it was not improbable that the driver was in hurry to finish decantation and over reached his responsibility.

7.4 From the assignment roster it is observed that:

- 7.4.1 3 officers in combination are assigned to shift management, cylinder filling shed management, Pump House and TLD Supervision without clear instruction on deployment in specific work areas.
- 7.4.2 The officer responsible for TLD operation, on the date and time of incident, has no past experience of LPG plant operation before his posting at Kochi LPG BP.
- 7.4.3 The workmen responsible for TLD 1 & 2 on the date and time of incident are experienced LPG operations personnel.
- 7.4.4 The multiple responsibility centres – spread over large geographical area – makes direct supervision almost impossible.

7.5 The process of TTs being taken inside the main gate and their consequent placement to the specific bay is not clearly recorded; the bulk TT driver is left on his own till placement in TLD Bay; and as both the male & the female ends of the quick release coupling are available at the bays, can connect the TT for loading practically unnoticed.

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- 7.6 It was observed that the bulk TT unloading SOPs are generic in nature and not site specific particularly when for this location has multiple TLD facilities and bulk TT unloading is a regular activity badly requiring site specific SOPs.
- 7.7 It was observed that the excess flow check valve of liquid line connected to the TT had sheared off from the shell of the Bullet. The broken excess flow check valve along with the 90 deg C elbow pipe, isolation valve and flange of the TT were found to be connected with the unloading arm. This resulted in loss of primary containment. It was further observed that the excess flow check valve of the vapour line of the bullet ruptured at a point where the excess flow check valve is connected to 90 deg elbow pipe. In this case the EFCV remains attached to the TT. Use of brass as MoC for the threaded joint of EFCV with the rest of the components having MS as MoC does not add to structural strength of this vital interconnection.
- 7.8 It was observed that the physical construction of additional bays (bay no15 & 16) was complete. It was further observed that the LPG headers were connected to the existing TLD-1 header and were charged with LPG. No physical barriers were set up to pro-actively debarring entry of bulk TT even by mistake. This simple step would have averted this incident.
- 7.9 The personal interaction with location in-charge, officers responsible for TLD, workmen responsible for TLD 1 & 2 and the security supervisor responsible for B shift of 10.09.12 indicates that:
- 7.9.1 All corroborated the view that responsibility of individuals in the roster is not formally described but generally left to understanding established by practice.
 - 7.9.2 All corroborated the view that the action of placement of the bulk TT in bay 15 of TLD 1 during the incident was taken by the driver of the bulk TT independently.
 - 7.9.3 The all-important person in the whole episode i.e. the driver of the concerned LPG bulk TT, who could have clarified many doubts, was not available as he was arrested by the local police (subsequently released on bail) and therefore, was not available for interaction. Even the Plant management had not been able to talk to him immediately after the incident as he was able to go out of the plant in the wake of mitigation action being taken by the plant fire fighting team after the incident.
 - 7.9.4 The security supervisor indicated that the main gate of the location was not closed immediately after sounding the fire alarm as is the SOP. But for this violation, the plant management could have had the opportunity to question him first to arrive at a better understanding of the course of events which would have enabled them to take effective corrective action.
- 7.10 Further, no satisfactory answer could be obtained for the following discrepancies:
- 7.10.1 The TT, as per plant record, entered the plant at 1445 hrs on 10.09.12 and the incident took place at around 1640 hrs i.e. almost 2 hrs after its entry.

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During this period, the concerned bulk TT driver was able to place 18 MT TT in broad day light in a bay which is yet to be commissioned; he was able to “obtain” the male end of the coupling; his lined up the TT for unloading and finally attempted to drive the TT away on being “advised” (by whom?) that this bay is yet to be commissioned without being detected by either the security or the BCW or the officer concerned raising serious doubt on the supervisory effectiveness.

- 7.10.2 The TT, as per plant record, entered without the other member of the crew i.e. helper / cleaner. In absence of any helping hand, there was no support / restraint available readily for the driver. The TT was allowed to ply without adequate crew as prescribed by the mandatory provisions of MV Act/Rules.
- 7.10.3 The concerned bulk TT driver’s being able to go out of the location even when the fire alarm was sounded after the vapour cloud consequent to the leak was detected. This raises doubts on the main gate security management system.
- 7.10.4 The Liquid LPG header of TLD 1 remaining charged in bay 15 & 16 even when the bays were yet to be commissioned.
- 7.11 The overall upkeep of the facility around the TLD-1 needs improvement in so far as housekeeping, painting, civil maintenance and drainage are concerned. The peripheral drain level with respect to ground level was uneven and the drain was clogged & overflowing. LPG vapour accumulation in TLD 1 was expected to flow through this drain discharging to canal outside the perimeter wall but the drain was not having any vapour seal.
- 7.12 It was observed that the perimeter of the plant is huge and there is wild grass growth alongside the boundary wall. It was further observed that there was no watch tower for aerial surveillance of the facility.
- 7.13 During demonstration of the TT decantation procedure it was observed the work men were able to perform the job. A need was felt to enhance the process skill of the floor officers on duty.
- 7.14 The plant has carried Risk Analysis during Feb’2011 and HAZOP in April’2011. The plant has also developed on-site disaster management plan.
- 7.15 The analysis of fire drill report and the log book of the fire engine reveal that though fire drill has been conducted on a particular date but its corresponding running of the engine during the fire drill was not logged in the fire engine log book.
- 7.16 The last MDT was conducted during 16 to 18th Nov’2011. There was no specific observation regarding TLD manning, SOP on supervisory effectiveness or bulk TT unloading system as practised in the plant.
- 7.17 The TT drawing was approved by the PESO on 23/02/99. It was observed that the TT had entered plant and was not aware as to which particular bay the TT needs to be placed for decantation. The TT was placed on the bay no.15. The subject bay no. 15 and the adjoining bay no.16 are the extension for which the final commissioning clearance from the PESO was yet to be obtained.

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- 7.18 Statutory licences of the plant were found to be valid.
- 7.19 It was observed that the system of issuing, renewal and closure of work permit is not clear to the operating people.
- 7.20 As per the GMS records gas alarms were noticed at around 16:30 hours on channel 43, 46 and 47. It was informed that these sensors were placed at bay no.3 and 6 of TLD-1.

8.0 Identification of Root Cause of the incident:

- 8.1 By analysing the record and submissions of the individuals concerned with incident, the following may be construed as the root cause of the incident:
 - 8.1.1 The LPG Bulk TT was allowed to be parked in Bay 15 of TLD 1 – which was reportedly not yet operational but still under construction – without any supervisory intervention indicating systemic failure.
 - 8.1.2 This was further compounded by absence of physical barrier in this bay. The absence of any such practice is corroborated by absence of any such barrier in any of the four such bays in the plant.
 - 8.1.3 As the TT was allowed to be parked in a non-operational bay without supervision, further safety precautions in the form of taking over the ignition key and placement of wheel chokes were also not taken.
 - 8.1.4 The driver was allowed access to quick release male coupling for fitment with the truck even when the placement was unauthorised. As the entire liquid header of this bay was charged with gas and complete with fitment of unloading arm & quick release female coupling, this one event could have compromise the whole system.
 - 8.1.5 The driver was allowed to line up the bulk TT for unloading in this bay by fixing the male coupling with the TT and also complete the quick release coupling male-female fixing indicating lack of supervision on the part of the employees deployed for the same. The TT driver was in any case not supposed to do the male-female coupling join by himself.
 - 8.1.6 Not only the TT was allowed to be placed and lined up without supervision, the driver was also allowed to attempt driving it away from the bay without decoupling the unloading arm.
 - 8.1.7 Absence of any break away coupling in the unloading line (in contravention of # 6.3(iii) of OISD STD 144) ensured entire break away thrust of the moving TT on the TT manifold and as a result the weakest links i.e. threaded EFCV housings of brass construction gave away in shear.
 - 8.1.8 Due to this failure, the EFCV of the liquid line got completely detached leaving a hole in the bullet (the EFCV of vapour line, however, held on to its housing stopping any vapour leakage in spite of the shear) through which the entire liquid content of the TT leaked to the atmosphere.

However, it must be kept in mind that the attempt to re-construct the sequence of events of the incident was severely handicapped as the most important person involved in the incident i.e. the driver of the said TT, was not available to the investigation team for personal interaction. It was indicated by the plant management that even they had not been able to interact with the driver after the incident as he, reportedly, left the location unnoticed through the main gate kept open even after the fire alarm was sounded.

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9.0 Recommendations:

- 9.1 Immediate corrective measure needs to be taken as follows to ensure that the aberrations do not recur in this or any other location:
 - 9.1.1 Drivers of Bulk LPG TTs are not allowed to place the vehicle in TLF bays for loading/unloading independently without marshalling by designated supervisors or plant security personnel.
 - 9.1.2 Facilities yet to be commissioned but under construction must be positively barricaded from inadvertent entry attempts.
 - 9.1.3 Drivers of bulk TTs are not allowed to line up their vehicles with loading / unloading arm at all. This job should be done by OMC workmen under direct supervision of officer responsible for TLD operations.
 - 9.1.4 Addition of new facilities in an existing plant must also be offered to OISD for PCSA after its due clearance by Internal MDT. Till this clearance, gas-in by any means should not be done and if necessary positively segregated by blinding inter-connecting joints / ends.
 - 9.1.5 Work Permits are issued with clear indication of the nature of the job instead of general reference to “cutting/welding” etc. For work fronts where construction work is on-going may be issued with work permit on a continuous basis rather than issuance and closing on day to day basis to ensure continuity of the required safety precautions at the work front as well as visible indication to others about status of the said work front. No over writing shall be done on hot work permits. All corrections must be done through clear cancellation and re-endorsement with authorisation signature.
 - 9.1.6 Fire Engine Operation records are maintained in line with fire engines’ actual operation including the instances of operations during fire / DMP drill.
- 9.2 The existing manning norm for specific work area- work site combinations (like TLD - 1 & TLD-2 separately) should undergo immediate review. This may be required to be done for the entire LPG operation function particularly in view of the recent spate of incidents in TLD area of a no. of other LPG BPs.
- 9.3 If necessary, location specific manning pattern keeping in view the peculiar circumstances prevailing in the said location shall be developed to ensure effective and direct supervision by officer and workmen so that individuals’ responsibility and accountability can be clearly established at all points of time.
- 9.4 Fool proof TT placement system is to be designed ensuring TT placement at the designated bay/ TLD shed with documentation build up endorsing acknowledgment of custody transfer points.
- 9.5 The role and responsibilities of the security, workmen and officers should be clearly defined matching the need of the location. While assigning individuals to such responsibilities, KSA fit must be kept in mind.

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- 9.6 The SOPs should be site specific and the training thereof to the operating personnel for handling normal and emergency situations shall be ensured.
- 9.7 As per the requirement of OISD STD-144, the unloading arm shall be provided with breakaway couplings (clause no. 6.3iii) which are not the case in this location.
- 9.8 The design of bulk LPG TTs needs to be revisited with respect to material of construction / protection / placement of the excess flow check valve to prevent loss of containment in case of any mechanical damage due to any impact / force on the manifold connections.
- 9.9 Adequate inventory of spares from the OEM must be maintained at the plant level to ensure integrity of critical equipment such as the quick release couplings of the loading/unloading arms in the context of findings of the OISD investigation into the another incident of similar nature.
- 9.10 While developing the ERDMP, due weightage should be given to total failure of containment in bulk LPG TT while under loading / unloading particularly in view of recent incidents involving such operations and deviations from OISD-STD-144 clause 6.3(iii).

(end of report)

Enclosures:

1. Plant & Vehicle documents vide **Exhibit A**
2. Plant Photographs **Exhibit B**

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Exhibit A

Pics showing EFCV condition after shear-off



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The errant TT in Bay 15 of TLD 1 under construction



The extended header connected with and charged thru the existing header even before the bay is declared ready for operation