CASE STUDY

OISD/CS/2023-24/**P&E/09** Dt.: 30/08/2023

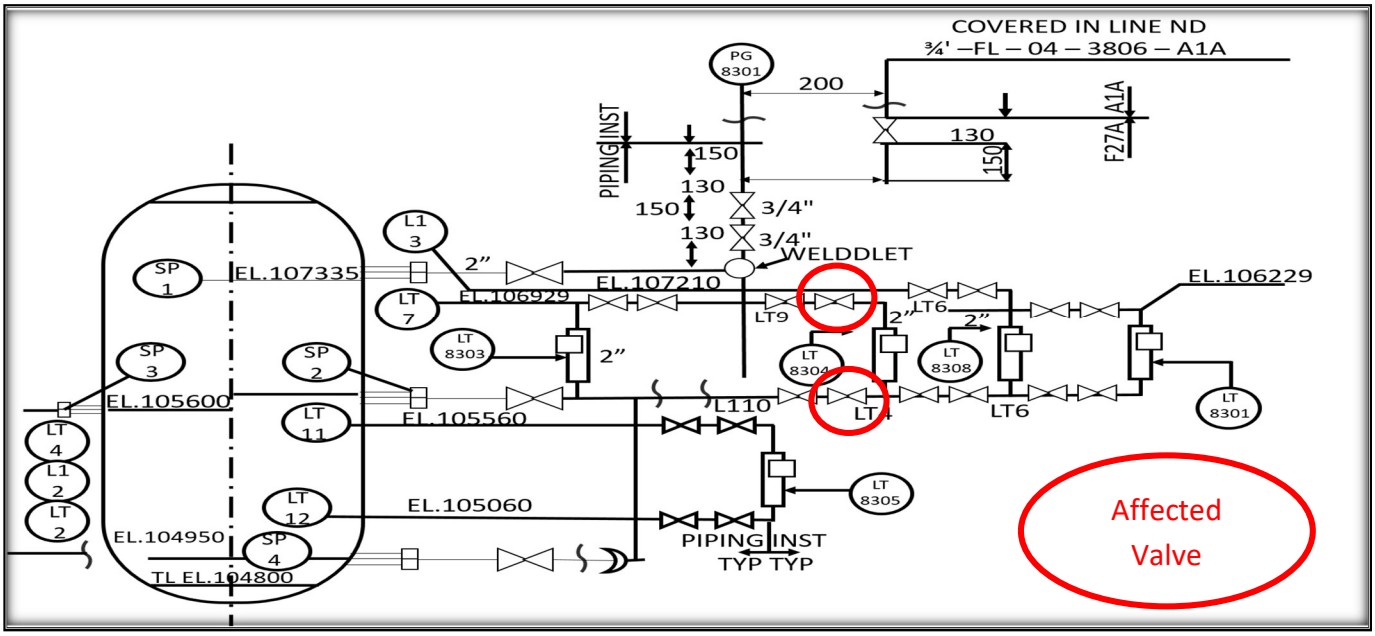
INTRODUCTION

Title: Major Fire Incident at HCU.
Location: Refinery
Loss/ Outcome: Production Loss & Property Damage

BRIEF OF INCIDENT

Explosion along-with major fire occurred in the vicinity of Cold High Pressure Separator (CHPS) in HCU unit. Operating personnel took emergency shutdown of the unit and depressurization activities were carried out by activating dump valve located at CHPS overhead line.

Firefighting activities were carried out by F&S personnel and fire was restricted to the source area within 20 min by continuous firefighting. N2 de-blinding in the RGC suction line upstream of suction MOV was carried out and N2 was pushed into the CHPS. However, the residual hydrocarbon of the system continued to burn. As there was no isolation valve in the High Pressure section upstream of CHPS to cut off the HC vapours coming into the separator, the hydrocarbon content of the system was allowed to burn. Finally, the fire got extinguished completely after 4 hours on the same day till the residual hydrocarbon from the separator got exhausted completely. Schematic representation of CHPS is given below:



Provided for information purpose only. This information should be evaluated to determine if it is applicable in your operations, to avoid recurrence of such incidents.

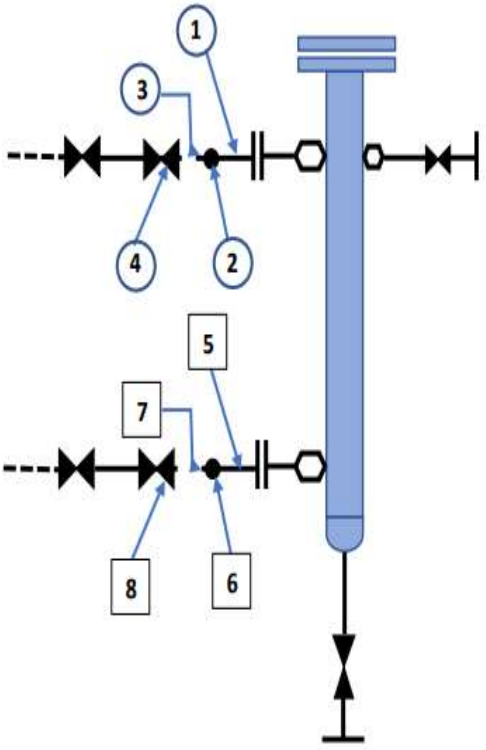
Incident Site Photos

OBSERVATIONS / SHORTCOMINGS

1. The CHPS had six standpipe level trolls. Three for hydrocarbon (HC) liquid level measurement and three for interphase (HC/sour water) level measurement. Each was provided with “Y” type welded, double isolation valves, in both low pressure and high-pressure tapings.
2. One of the level troll standpipes meant for HC liquid level measurement was found sheared from the 2nd isolation valve, both on the LP as well as the HP side.
3. The pressure of the system was 155 Kg/cm2g. Fluid in the system was HC mixed with Hydrogen.
4. Release of the fluid resulted in sudden explosion followed by major fire.
5. Pipe racks including pipes and supports, cable trays, within 15-20 meters from the leakage point were found damaged. Electrical and Instruments cable duct in the pipe rack were also found damaged.
6. All the 4 “Y” type welded valves (2 in LP Tapping and 2 in HP Tapping) of the particular standpipe level troll were new. They had been replaced in HCU turnaround maintenance done in 2023 as the previous valves were passing.
7. Remaining troll standpipes were intact, and no damage was observed. No other valves had been replaced.
8. Failure of both the valves occurred in the valve body, just before the weld joint. Weld joints between troll standpipe piping to valve body was found intact.
9. Valves originally installed were M/s Edwards, USA make. (Size 2” 1500#, Type: Y Type Globe valve)

10. Failed valves were supplied by an indian vendor and procured in the year 2020. Total 8 valves had been procured for this service. 4 had been used and remaining 4 were kept in workshop as spares.
11. Valves, after replacement, had been successfully hydro tested at site at 208 Kg/cm2g pressure and witnessed by refinery inspection department.
12. As per the reports submitted by the vendor, Third Party Inspection (TPI) was carried out at vendor workshop during valve supply to refinery and no abnormality was observed in the report. All the tests, as per Quality Assurance Plan (QAP), were witnessed and endorsed by TPI. However, As per TPI agency, the said valves were not inspected by them and the documents submitted by vendor to the refinery was a forged document.
13. The stage wise inspection of the valve during manufacturing at the vendor shop is not evident.
14. As confirmed by the operating personnel, no leakage was reported during leak test with hydrogen at system pressure of 155 Kg/cm2g as part of start-up procedure.
15. As per technical specifications and QAP, the valve body was supposed to be integral forging. However, manufacturing defect of the valve was noticed after detailed analysis carried out for identical spare valve from the same lot.
16. Material of Construction of old valves was Carbon Steel. However newly supplied valves were observed as Carbon Steel + Difference in bevel ends (Carbon Steel in one side and SS-410 in the other).
17. PMI of the relevant failed valve was carried out. It was observed that P-5 pipe was used in one side in deviation from the manufacturing guidelines.

S. no	Description	Chemical Composition					PMI Result
		Fe	Mn	Cr	Ni	Mo	
1.	LT Pipe Top	96.8	0.76	0.19	-----	-----	CS
2.	LT Pipe Weld Top	96.5	0.15	0.09	-----	-----	CS
3.	Break Point Top	93.2	0.76	5.78	-----	0.5	P5
4.	Valve Body Top	98.5	0.92	0.42	-----	-----	CS
5.	LT Pipe Bottom	98.7	0.96	0.12	-----	-----	CS
6.	LT Pipe Weld Bottom	97.8	1.15	0.78	-----	-----	CS
7.	Break Point Bottom	94.9	0.71	3.94	-----	0.5	P5
8.	Valve Body Bottom	96.4	0.80	-----	-----	-----	CS



18. Bevel end orientation was not in line with the original valve. Sharp ends were observed which might lead to stress concentration. Refinery did not notice this deviation during acceptance of valve and prior to installation.
19. Bevelled end of the failed new valve was machined off in a boring machine in refinery workshop and the observations are as follows:

    - ✓ Mark of the welding was observed at the end of valve body.
    - ✓ An elongated circular discontinuity observed at its vertical to bevel end interface. The fillet welding also has discontinuity and other defects.

20. Record of any NDT, additionally carried out on these 8 valves ('Y' type globe valves) during acceptance at warehouse and before installation at site were not produced by refinery.
21. Three (3) electrical Junction Boards on the CHPS standpipe platform were checked and loose fittings were observed. Bolt was missing in one JB located at about one metre from the failed valves.

REASONS OF FAILURE / ROOT CAUSE

Valve Failure & Leakage:

1. The newly installed valves had manufacturing defects. Brittle fracture might have happened due to hydrogen embrittlement at the bevel end of the "Y" type globe valve which resulted in release of hydrogen, hydrogen sulphide and hydrocarbon followed by explosion and fire.

2. Apparent possibility of submission of false or fabricated third party inspection certificates for the lot of failed valves supplied by the vendor. Probably the valve lot might not have been tested at 392 kg/cm2 in the vendor premise as required for ensuring its integrity. Though refinery has tested the valves at 208 kg/cm2 after installation in the HCU plant, the test pressure of 208 kg/cm2 might not have been sufficient to detect the manufacturing defect.

Source of Ignition:

3. The sheared off portion of the stand pipe might have hit the surrounding objects/ pipes resulting in in spark generation.

4. A possibility also exists that ignition would have occurred from the electrical junction box (Gap in the electrical junction box) existing in the vicinity or discharges of accumulated static electricity on account of discharge of hydrogen at high velocity.

RECOMMENDATIONS

1. Following should be ensured to prevent manufacturing defects.
    a. Proper scrutiny of TPI witness test certificates during material receipt.
    b. Suitable mechanism or confirmation & verifications of inspection certificates directly from TPI. The material supply tender may include provision for direct submission of copy of witness test certificates from TPI to user. TPI to submit the inspection release note and stage inspection progress directly to the entity with copy to equipment manufacturer.
    c. Suitable provision to be incorporated for approval of vendor selected TPI and may also make surprise inspections to check the quality of TPI inspection.
    d. Industry should also directly appoint the TPI rather than selection by the vendor. This will improve monitoring of inspection activities and can avoid fraudulent test certificate generation.
2. Standard Maintenance Procedure (SMP) should be developed, including joint inspection by Mechanical & Inspection personnel, for thorough checking during valve replacement in critical service before installation.
3. A provision exists of licensing by API for the agencies manufacturing items as per API code. Though it is voluntary in nature, purchasers may examine considering API licensing monogram requirement as a pre-requisite in the supply tender for such critical items manufactured as per API code.
4. IS/ISO 15761 is considered equivalent to API 602. Purchaser may examine considering the equivalent Indian standard (IS/ISO-15761) in their purchase order. This may facilitate initiating suitable actions by BIS in case of deviation in manufacturing is noticed.
5. 100% Positive material identification (PMI) shall be ensured for all critical high rating valves (Criticality shall be defined by the industry and the same shall be authenticated) in high pressure section at site, including all carbon steel loop, in order to identify the dissimilar metals. PMI should be ensured for both the sides of the weld joints in such valve installations. Industry shall devise the criticality for the requirement of PMI.
6. Operator must ensure that all electrical equipment / fittings fitted in the plant area are meeting the hazardous area classification and all such fittings should be maintained properly.
7. All the cable glands, Junction boxes shall be inspected for tightness as per OISD-RP-147 and records shall be maintained.
8. Continuity jumpers shall be provided for hydrogen, LPG, pipelines, equipment's etc to ensure the resistivity is within the stipulated limit.